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SCIENTIFIC AMERICAN SUPPLEMENT

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BEACONS FOR AIRMEN.—[See page 164.]

A New Way of Selling

Manufacturing Cost Plus X Percentage

SEVERAL years ago a business organization at Berlin called Zentrale für Weinvertrieb introduced into the retail trade the method of selling "manufacturing cost plus 10 per cent," that is, the firm pledged itself not to charge its customers for the goods purchased more than the actual cost and an additional 10 per cent, which latter was to represent commercial profit. This novel method of selling lifted the veil from the secrets of commercial calculation, which up to then had been carefully guarded, and not only exposed to public gaze the greatest secret of all, the amount of profit, but even gave a pledge to limit this profit in all cases to a fixed minimum. It was, therefore, only natural that the friends of the new method of selling should be drawn from the ranks of the purchasing public, while its opponents, who attacked it with great violence, as the German courts can testify, belonged to the commercial class. There were members of this class who felt their existence to be threatened and who regarded the new way of selling as unfair competition. In commenting on the new method, O. Bechstein says in No. 1287 of *Prometheus:*

"Notwithstanding all opposition, the new method of selling has proved to be full of vitality; it has won adherents in the retail trade, and of late large orders have been given in the manufacturing industry in which the price has been set on the basis of actual cost plus X per cent. So it is possible that, in the course of time, many others engaged in manufactures and commerce will gradually grow more friendly to the new method of selling and will make use of it. Consequently, it is of interest to examine, briefly, whether the general introduction of the new method would be desirable, whether it represents an economic advance, what advantages it possesses over the old method of selling, in which the buyer never learned the profit of the seller, and what are its disadvantages.

"The formula, 'actual cost plus X per cent,' indicates at once that the most important thing for any business based on its principles is to determine correctly the manufacturing cost, its amount and its constituents, which the buyer must have the right of investigating (in the wine business first mentioned, the accounts are examined by an auditing company and any surplus over 10 per cent is returned to the purchasers). This producing cost includes all expenses incurred by the seller in obtaining the commodity and transferring it to the buyer up to the completion of the sale. Consequently, it includes the original purchase price, expense of purchase and of transportation to where the stock is kept, expense of keeping in stock, office expenses, expenses of selling, advertising, packing, dispatching, etc., and, in addition, the indirect charges caused by the loss of interest in granting credit, bad debts, the expenses of collection, etc. In short, the cost of a commodity includes, according to a decision of the Royal Supreme Court, of Berlin, all expenses which the commodity has entailed upon the seller himself up to the actual sale and the receipt of the selling price. The interest upon the business capital, though, is not included in the cost, but is to be met out of the profits of the business, which, therefore, on the basis of cost plus 10 per cent does not amount to 10 per cent but only to the difference between this percentage and the interest on the business capital. The previously mentioned business Zentrale für Weinvertrieb designated, therefore, in my opinion, very correctly the additional 10 per cent as 'turn-over charges,' that is, charges for the work expended in gaining the turn-over, the sale and the obtaining of the commodity, with, in addition, the interest on the necessary capital which the seller must have at his command."

It is easy, with the aid of the explanation of the meaning of cost plus X per cent just given, to prove that the selling method of prime cost plus X per cent represents a real economic advance, because it offers the purchaser the certainty of obtaining a good quality of his commodity at the most favorable price, as it is of much importance to the seller to keep the cost of the commodity as low as possible. Moreover, the seller no longer gains any advantage from debasement or underweight, and, lastly, the ability of the merchant is not only of benefit to himself, as formerly, but automatically benefits the buyer as well.

"At the first glance it might seem that the seller, contrary to what has just been said, would have a direct interest in a high cost, as this more than formerly determines the amount of his profit. This idea, though, is incorrect. The seller, who, in one sale of a commodity, cannot earn more than X per cent, is naturally led to seek this X per cent as often as possible, to strive after the largest sales, in order that the business may yield him the necessary or desired annual profit. It is evident that larger sales can be made at low prices than at high ones, so that in the new method of selling, consequently, the seller, in order to obtain larger sales, is forced far more than by the old method to strive for the lowest possible cost in every way—by favorable purchase, the smallest possible business expenses, great caution in granting credit, the avoidance of keeping goods long in stock, etc.—all of which naturally is of great benefit to the purchaser.

"It is evident that all inducement to adulterate the commodities by admixture of inferior quality, and to deception as to size and weight, must be completely checked by the new method of selling, presupposing, of course, that the buyer can test the calculation of prime cost. The seller would obtain no profit from manipulations to lower the cost, the purchaser would simply buy more cheaply although he would get poorer commodities. If, namely, the seller were to sell 100 liters of spirits of wine, the cost of which might be 150 marks, at a 10 per cent advance, that is at 165 marks, or if he diluted the 100 liters with water until it made 110 liters and then lowered the prime cost of 110 liters to 150 marks, he would never by the sale make more than 10 per cent of 150 marks."

In discussing this topic further, the writer in *Prometheus* says: "Commercial acuteness, which in the new method of selling must naturally have for its aim only the reduction of the prime cost for the purpose of gaining larger sales, as a matter of course benefits the buyer also, for he shares to a large extent in the advantage of a reduced cost. In addition to the advantage he derives from the successes of mercantile skill in business management—reduction of business expenses—the buyer also derives great advantage from the skill of the seller in acquiring the commodity to sell—as in the seller seeking cheaper markets for supply, his favorable purchase contracts, his use of favorable opportunities in the markets for commodities and money, and fortunate speculation. The buyer has, on the other hand, to bear his share in the merchant's mistakes, only, however, when he buys at the increased prices imposed by unlucky speculation and does not prefer to go to competitors who are cheaper because their speculations have been more fortunate. The buyer would be able to do this in the retail trade; he frequently would not have this choice in the wholesale trade and in manufactures."

Looked at as a whole, therefore, the economic advance in the new mode of selling is in this: That the buyer commonly buys more cheaply than by the old method, and that the seller is led to arrange the management of his business so as to combine the utmost energy and economy. In this way the national economy enjoys the advantage of a more favorable intercourse between producer and consumer.

As may be inferred from what has been said, conditions are comparatively simple in the retail trade. At the present time, however, the new method of selling seems about to enter the field of manufacturing, its first entry here being in the ship-building trade, on the one hand in spite of, and on the other probably just because conditions in this trade are much more unfavorable. The Hamburg-American Company has commissioned the Vulcan Company of Bremen to build two new mail steamers. The same principle has been followed for years by the White Star Line. The price to be paid for these Hamburg steamers is not, as formerly, one previously agreed upon, but the shipyard which constructs them is to receive the prime cost plus X per cent.

In ship-building, though, the determining of the prime cost is by no means so easy as in the retail trade, even though this cost may be composed in general of the same items. The small financial success of the large German ship-building yards may be traced in no small degree to the fact that in the calculation of fixed prices large errors may slip into the determining of costs. Many months intervene between the calculation of the cost of a large ship and its completion, during which time, to mention only one point, the prices of necessary building materials can easily undergo large fluctuations. Such fluctuations, when the value of the materials for construction runs into the millions, must result in great differences in the prime costs. Other factors which must be regarded as having a strong influence on the prime cost, and which vary as time passes, are the rate of wages, the condition of the labor market, and the advance in technical methods and organization of business.

"Under these conditions," says the writer in summarizing the question of the new selling method of shipyards, "two cases, therefore, are possible. Either the shipyard adds to the calculation of cost a lump sum for security—and this can only be done to the moderate extent that competition allows—thus making the buyer run the risk of paying too much if it should afterward prove that the additional amount was unnecessary or too high, or else no additional amount is added, or the amount is not made high enough, and the shipyard has the loss. In this case, consequently, both sides would profit by the introduction of the new method of selling, as would also the nation economically.

"The difficulties in determining the costs of work done in a shipyard are so great that the investigation of an auditor would not be sufficient to secure satisfactorily the interest of the buyer; for the whole organization of the shipyard, its working apparatus, the technical ability of its employees, etc., do not come under the survey of a purely mercantile investigation of the books. In this case, the buyer must obtain for himself a survey of the total working of the shipyard by means of his own men who have been trained both technically and in methods of organization. By so doing, he can supervise the correct determining of prime cost, the amount of which is so important to him."

There are unquestionably serious doubts as to the effect upon the independence of a shipyard of such an examination of its internal conditions. At the present moment, it can hardly be settled whether these doubts are so important that, as is assumed in various quarters, they must lead to the direct combination of ship-building with the shipping trade, or whether here, as in retail trade, the cards can be shown, that is, trade secrets can be published, without entailing heavy damage. This, however, could be done in the case of the shipyard by using the principle of prime cost plus X per cent, as in shipyards the financial results could be determined by comparison with previous work, for a large part of the risk of construction could be thrown on the buyer, while he, on the other hand, could protect himself from excessive charges. Experience has shown in retail trade that the principle of prime cost plus X per cent in making sales can be carried out advantageously for seller, buyer, and the national economy. It will also be applicable to many cases in the wholesale trade, and there may be a goodly number of other occupations besides shipyards, among which agriculture would be by no means the last, which could work well and without any great difficulty of organization on the basis of prime cost plus X per cent.

Conditions appear to be favorable for the application of the new principle in the building trade. The great German co-operative supply associations, especially, which incline more and more to develop into associations for production, ought to consider seriously, in the opinion of our author, whether their work would not be more satisfactory if they bought from producers at the rate of prime cost plus X per cent, than if they become producers themselves.

History in Waste Paper

A Contract 2,215 Years Old

A CONSIDERABLE audience assembled at the Royal Society's rooms, in London, recently heard from Mr. J. de M. Johnson a remarkable story of how light is being shed on ancient history through the medium of papyri taken from mummies unearthed in the course of excavations under the auspices of the Egyptian Exploration Fund. The period covered by the discoveries was 1,000 years in the Græco-Roman era, and the localities were Antinoë and Abydos and the desert region around.

Waste papyri, he explained, was then much used in the process of mummification, and by removing the paint from this by means of acid there had been revealed valuable testimony to the literature and life of the period. Parenthetically, he remarked, the nearest approach we had now to this papyri was papier-maché, but he feared this product would never reveal the secrets of the past. The earliest dated character papyrus discovered was a contract for the sale of wood about 301 B. C. He hoped it would be possible for a series of lectures to be arranged which would reconstruct from papyri some centuries of Egyptian history and life. In some of the graves a considerable quantity of pottery had been found, and one bowl bore the inscription: "Take of the medicine one sixty fourth part daily."

A number of lantern slides were shown revealing the nature of the country where the excavations are being made, and showing the different methods used in mummification and the varieties of decoration employed. At first the casings for mummies seemed to have been made for the particular deceased person they inclosed, as appeared from the inscriptions, but, said the lecturer, there were indications that later on they were kept in stock for any purchaser who turned up.—*The Daily Telegraph.*

Telegraphing Pictures

Recently Prof. Arthur Korn read a paper before the Berlin Society of Electricians, on the present state of picture telegraphy, with especial reference to a step relay for strengthening the current employed in the selenium method. The new apparatus for carrying out this system was presented, as was also that for the ordinary telautographic method.

Since the spring of 1907, when the first telegraphic transmission of pictures between München and Berlin by Korn's selenium process took place, ceaseless efforts have been made to perfect not only this, but also the ordinary black and white process. The first is based, as is well known, on the sensitiveness of selenium to light, and its property of varying its electrical resistance with the amount of illumination. A photograph in the form of a transparent film is wound about a glass cylinder, and by the aid of a system of lenses the light of a Nernst lamp is concentrated on one part of the photograph; the light passing through the film is thrown on a selenium cell, which is more or less strongly illuminated, according as the part of the photograph is less or more transparent. When a current from a constant battery is passed through a selenium cell to a distant receiving station, the intensity of the current received will correspond to the light tones of the different places in the original photograph. The sending cylinder is set in rotation, and at every turn is shifted a trifle parallel to its axis, so that all parts of the photograph will be passed through successively by the light rays and the picture will be reproduced at the receiving station. The details of the receiver, the string galvanometer used by Prof. Korn, and the improvement of the process by lessening the inertia of the selenium by the aid of Korn's so-called selenium compensator, have all been described in the technical press.

In 1907-1909, by the aid of this selenium process, many transmissions were made between Berlin and Paris, Paris and London, London and Manchester, Berlin and Copenhagen, Copenhagen and Stockholm; and the *London Daily Mirror* showed very often, in its morning edition, pictures from Manchester and Paris, which would otherwise have come a day later by post.

In these transmissions there was found an undesirable feature: the currents were very weak—at most a milliampère (1/100 ampère)— and for this reason the transmission was often subject to interruptions from side conductors, which were stronger than those for transmitting the picture. The greatest desideratum for picture telegraphy was therefore so to improve the process that the currents would be considerably stronger. While Prof. Korn worked on this problem, he and Prof. Glatzel worked out the telautographic method, using also, at the receiver, the string galvanometer, but at the sender, not the sensitiveness of selenium to light; they went back to a principle 70 years old.

The telautographic method served first only for transmission of writing and drawings; these are transferred in the form of a non-conducting material to metal foil, which is then whapped about a rotatable cylinder. While the cylinder turns, a fine metal point touches it, and by reason of its regular lengthwise movement touches every part of the subject to be sent, making a fine spiral line over the entire foil sheet. Every time that the point touches a non-conducting part of the sheet (that is a part of the writing or drawing) no electric impulse is sent; whereas, when it passes over a conducting portion between lines or points, a current is sent to the receiving station, enabling the reproduction of the original at the latter place.

This process, as carried out in early times by Bain, Bakewell, Caselli and others, was too slow; but the introduction of the string galvanometer in the receiver by Korn, and the photographic registering, has increased the speed of transmission so greatly that the process is practically useful, not only for the transmission of handwriting and drawings, but also for photographs, which formerly have had to be put into black and white by a Levy screen.

So, recently, there have been very good results obtained between such different places as Berlin and Paris, Paris and London, Paris and Monte Carlo—results often better than with the selenium process. This process can work with currents of 10 to 20 milliampères, and that is the reason why it has been preferred to the selenium system.

It was, however, easy to see that the latter system would come to its own again when it was a matter of great distance between sender and receiver, and especially where the transmission took place through a long submarine cable, which by reason of its so-called capacity does not permit of many impulses per second.

A main condition for the usefulness of the selenium method for this purpose was, that the current could be considerably increased in strength; and now we come to the solution which Korn, with the help of his assistant, St. Carazzolo, has worked out, and which now permits telegraphing photographs to any desired distance, even by submarine cable between Europe and America. The time of transmission is, of course, longer in proportion to the "electric capacity" of the cable, and the transmission is naturally dear; but still it is possible, and can be effected with all desired exactness.

In thus strengthening the current, Korn takes advantage of the property of the sparks of high-frequency currents (the so-called Tesla currents) to light arcs. The weak currents are conducted through a sensitive needle galvanometer, which conducts the high frequency currents to a determined spark section, and every position of the galvanometer needle, that is, every zone of the photograph, creates a strong current arc on the spark section, but only when the weak Tesla sparks arrive. So for every position of the galvanometer, there is only one certain arc; a certain strong current circuit is closed, and with these strong currents all that is desired can be done. One can either send one part of the strong current into the line, or still better, use it for making a perforated strip, which represents the picture, and from which the latter can be transmitted over the line with the speed of transmission permitted by the latter. And finally one can, with the aid of the strong currents which accompany the different tones, send alphabetical telegrams which may be sent like ordinary telegrams and serve to reproduce the picture at the receiving station.

The system permits of application in wireless telegraphy of photographs; it can also serve to show halftone engravings at a distance, by rotating a great number of electric arcs (for instance 100), by using in the transmitter a great number of styluses traveling over the original picture, and suitable weak current relays in the receiver which send the Tesla sparks at the right time to light the electric arcs which are interrupted as long as the Tesla sparks do not reach them.

New Casting Machine

For Making Perfect Pressure and Die Castings

The production of sound castings is often a very difficult matter in the foundry. For some mysterious reason blow-holes will occasionally appear, resulting in the "scrapping," possibly, of many valuable castings and the consequent waste of molders' time. Pressure casting is now coming into use, with the object of securing both castings free from blow-holes and—where die-casting is also adopted—castings of good surface, since they have not been in the sand.

Just how the pressure on the molten metal—obtained from a hydraulic press, gas pressure, or liquid pressure due to a head of metal—acts in the direction of securing castings free from blow-holes is a question that is still being debated. The probability is that since pressure facilitates the solution of gases, the gas, which, left to itself in the metal, would cause blow-holes, is caused by the application of pressure to be retained in solution and to occupy only an infinitesimal part of the space it would normally occupy in the molten material, so that when solidification takes place the cavities left are so insignificant as to be of no practical importance. It has been shown by Sexton that under the pressure of ten tons per square inch, which is often exceeded when steel is cast under hydraulic pressure, any separated gas bubbles in the molten metal would be diminished to about 1/3,000 of their normal volume. This fact certainly indicates a very valuable attribute of pressure casting, a system now applied to metals other than iron and steel.

Particularly is this the case with alloys such as Babbitt's metal and zinc and aluminium alloys, all of which lend themselves not only to pressure casting, but also to casting in dies.

A distinctly novel form of automatic pressure diecasting machine, which appears to open a new field in the direction of rapid and clean casting, has just been perfected by an English firm of engineers. Forming the base of this machine there is a furnace containing the necessary crucible to carry the molten metal. Bolted to this is a neck-piece, on top of which is fixed a domed cover, near the center of which is formed a pocket, having screwed into it a circular block of specially hard metal, bored out to form a taper nozzle, and slotted to take the sprue cutting bar. In this pocket and around the taper nozzle is a small furnace which keeps the metal perfectly molten, right up to the time of entering the die. Held in place by means of a gland and stuffing-box on the underside of the nozzle is a tube of refractory material, which passes down through the molten metal to within about half an inch from the bottom of the crucible. Through a gland in the domed cover a spindle runs down into the crucible, carrying two perforated disks, which are plunged up and down in the molten metal by means of a hand lever, thus keeping the metal well agitated. A hole and cover for same is also placed in the domed cover to allow of the crucible being filled without removing the cover. Hinged to the domed cover is a plate, to which is fixed the bottom half of the die from which the casting is to be made, and having in the center a hole to register exactly with the nozzle before mentioned in the circular block of hard metal, and also with the filling hole in the bottom half of the die. The hinged plate referred to is tilted back into any desired position by means of a suitable bevel and worm gear. Screwed into the hinged plate are three bright mild steel pillars carrying a bridge piece through the center of which works a double-threaded quick running screw, operated by a heavy hand-wheel or cross-bar at the top and carrying at the other end a plate registering on the three bright pillars. This plate carries the top half of the die. The domed cover, together with the center tube agitating disks and all the top gear, are capable of being thrown back by means of a worm gear, thus allowing of ready access to the crucible.

The process of casting is as follows: The metal to be melted is placed in the crucible through the filling-hole before described. The furnace is lighted, the bottom half of the die is fixed to the hinged plate, and the top half of the die is fixed to a plate carried by the quick-running screw. This is now run down so that the top and bottom halves of the die are brought tightly together. Here we may say that when it is necessary to use a multiple part die, a convenient detachable arrangement is provided to work horizontally in conjunction with the vertical clamping arrangement already mentioned. The sprue cutting bar is put into position so that the molten metal cannot pass through the nozzle, and the hinged plate is clamped, down. Connected to the neck-piece is a cylinder of liquefied gas, the valve controlling which is now opened, allowing the gas to exert pressure on the top of the molten metal in the crucible. The sprue cutting bar is now pulled back, thereby allowing the metal to be forced up into the die. The die being full, the sprue cutting bar is pulled back again, thereby stopping any further flow of metal, the hinged plate is unclamped, and the whole of the top gear thrown back, by means of the bevel and worm gear, onto a suitable table; the top half of the die is now pulled up by means of the screw, and the casting is automatically knocked out of same by means of three rods carried on a bridge piece and which run into the top half of the die nearly down to the casting when the two halves of the die are together. The whole top gear is now thrown back, the hinged plate is clamped down, the two halves of the die are brought together again, and the sprue cutting bar (out of which the small piece of metal, cut away, has been punched by means of a lever punch carried on a hinged plate) is again put into position to allow the metal to flow into the die, and the process is continuously carried on as described. It will be noticed that the dies are kept at the most suitable temperature for casting, owing to their being directly in conjunction with the small furnace, while at the same time no flames come into direct contact with the metal, thus avoiding oxidation.

Great pressure can be exerted on the molten metal, as when the liquefied gas is brought into contact with a hot substance the expansion is such that, at a temperature of only 45 deg. Cent., a pressure of 100 atmospheres is obtained, and proportionately higher pressures can be maintained according to the various temperatures worked at. The gas used is an inert one, and therefore has no action on the metal; neither is it absorbed by the metal.

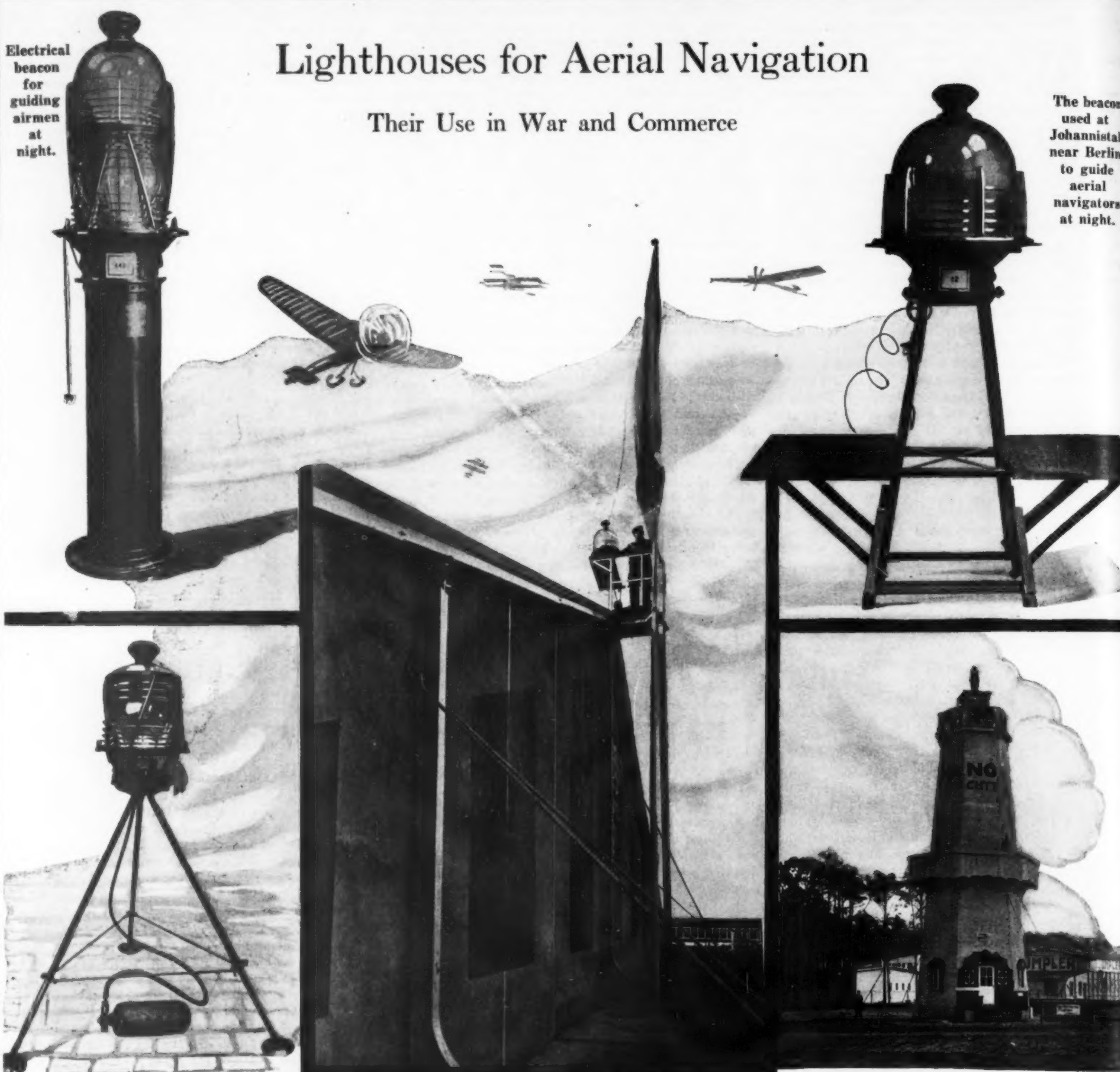
The machine would appear to be far in advance of anything that has yet been made for die-casting, and though it will take dies up to 9 inches square, machines to take dies considerably larger are being designed. Comparatively few machines have been brought out to deal with alloys containing a large percentage of pure aluminium, owing to the fact that aluminium attacks wrought iron or steel when molten, and also shrinks and cracks during the process of solidification in the die. The dies for the above machines have received special consideration, as it has been difficult in the past to design a die which did not produce porous castings or form air locks when used in connection with alloys containing a large percentage of aluminium.—*The Daily Telegraph.*

Refractive Index of Radium Emanations

A. W. Porter and C. Culbertson describe in the *Journal* of the Radium Society experiments made to determine the refractive index of radium emanations. The difficulties lay in the small quantity of gas available (1/10 millimeter^3) and the difficulty of keeping the gas pure. A specially designed Fabry-Perot interferometer was used. The vessel into which the emanation was introduced had two plane-parallel faces (distance apart, e), partly silvered in the insides. The ordinary Fabry-Perot fringes were obtained with a vacuum between the plates, the emanation was then introduced and the refractivity determined from the number n of bright bands which passed over a fixed point in the observing telescope, i. e., $\mu - 1 = n\lambda/2e$. Owing to the difficulty of working with the pure emanation and to the limited supply available, no definite values have so far been obtained, but the results show that the refractivity of the emanation is higher than that of any other known gas and at least twenty-five times that of helium. From certain theoretical considerations of the ratios between the refractivities of the inert gases the authors conclude that the value ought to be about forty times that of He.

Lighthouses for Aerial Navigation

Their Use in War and Commerce



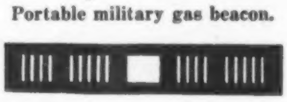
Electrical beacon for guiding airmen at night.

The beacon used at Johannistal near Berlin, to guide aerial navigators at night.

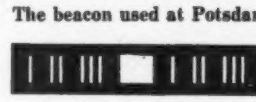
Portable military gas beacon.

The beacon used at Potsdam.

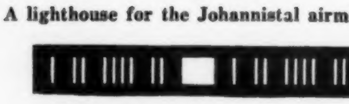
A lighthouse for the Johannistal airmen.



Light signal known as mark 45.



Light signal known as mark 123.



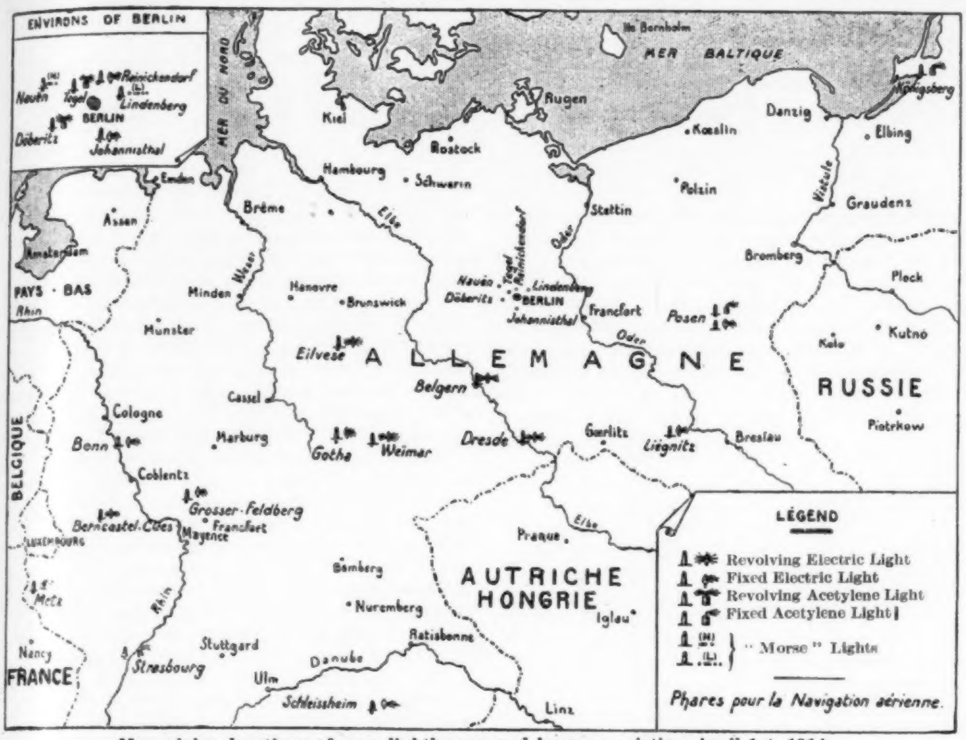
Light signal known as mark 1242.

To be of real use in war, aeroplanes will have to be flown at night. Their pilots would, in this way, be at the right spot for a reconnaissance by daybreak, or, in cases where the hostile troops are protected by day from aerial investigation, the pilots would be able by night flying to judge the contour and arrangement of a camp from the bivouac fires and lights. Even in times of peace, night flying will become necessary to those who wish to make long flights in a limited space of time. Night flying, though, either for warlike or peaceful ends, requires practice. In order to make such flights possible, in the opinion of Raoul Volens, who writes in *Aerophile*, the main routes of the air must be marked out, so that the aviator may know at any moment where he is, where he can land, and what obstacles he may meet. France, says our author, has done nothing in the matter, but Germany has been working on the problem for over a year. Her aim is to enable her military aeroplanes and dirigibles to start and land at night on all the aerodromes of either her eastern or western frontier, and to transfer her aerial forces quickly from one frontier to the other at will. To this end she is using what may be called lighthouses and beacons on her frontiers and connecting routes. There are twenty-one such lights already, generally at sheds for dirigibles and aeroplanes, which have been located with the same strategic end in view. The lights are of different kinds. The very powerful ones, the real aerial lighthouses, are to aid the aviator to find out where he is. Lesser ones are to point out the dangers he could not know beforehand, for by night a pilot can see vaguely the main outlines of the landscape, but he could not see until too late a very high tower or an electric wire. A third class of still weaker beacons are to aid in making a landing. In Germany the light was first thrown toward the heavens in a cone with a vertical axis and a small angle at the summit. It turned out that these lights could not be seen unless close by, and a beacon ought to be seen at a long distance. Flying at night is not done at a very great height, probably at not more than 500 to 800 meters above ground. The axis of the pencil of rays should, therefore, be very slightly inclined toward the horizontal, ascending in most cases, and descending only when the light is set on a high mountain. The intensity of the rays should decrease from the horizontal toward the vertical, where it should merely be sufficient to be seen from an aeroplane flying at 4,000 meters.

Another difficulty to be solved was the identification of these beacons. This could not be done with colored glass, as such glass absorbs a large amount of light, except for landing lights. For most of the other beacons, following the example of marine lighthouses, fixed, revolving and flash lights have been adopted, while still another class is arranged to throw a series of flashes of greater or less length, thus transmitting Morse signals. These last mentioned lights are called "Morse beacons."

The only lights of peculiar construction are the landing beacons. Those constructed by the Pintsch Company are intended to show the aviator in what direction he should land. They are sunk in the ground of the aerodrome and covered with a thick glass on which the aeroplane can alight and run. Their arrangement is the following:

A large white light 1 meter square is set in the center of the aerodrome. At 80 meters from this, following the points of the compass, there are four red lights which are connected by a subterranean channel to a series of contacts worked by a vane. When the beacon is in use only the central white light and one or two of the red lights are in action. Should the wind be north the red light to the north of the white light burns; if the wind comes from the northwest, the red lights to the north and west are lighted. When the vane turns, the red lights which no longer correspond to the direc-



Map giving locations of aero lighthouses and beacons existing April 1st, 1914.

tion of the wind are extinguished and are replaced by the light or lights which agree with the new position of the vane. When there is no wind at all only the central white light is visible. The aviator is thus instructed as to the direction of the wind near the earth and can maneuver so as to land facing the wind, or when the wind is negligible at the ground he is also notified of this fact.

The accompanying map from the *Aerophile* shows the aerial lighthouses and beacons existing in Germany on April 1st, 1914, and indicates the characteristics of these lights. According to our authority there are twenty-one of them, as follows:

1. Belgern-on-the-Elbe, in Prussian Saxony: revolving electric light flashing once in every 1.5 seconds, 72 meters above ground, 150 millimeters focal distance,

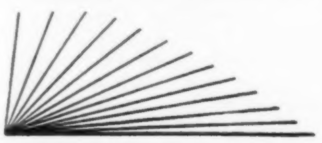


Diagram illustrating direction and relative intensity of rays of light employed.

7,000 candle-power; gives warning of high-tension cables, and is in course of construction. 2. Bernkastel-Kues: revolving electric light giving two flashes, 425 meters above sea level, 150 millimeters focal distance, 250,000 candle-power; opened in March, and shows where aerodrome is. 3. Bonn: fixed electric light with Fresnel lens or circular disk of stepped prisms, 25 meters above ground, 8,500 candle-power; gives by series of flashes the number of the station; belongs to the municipality. 4. Döberitz: revolving acetylene light flashing every 3 seconds, 50 meters above ground, 250 millimeters focal distance, 27,000 candle-power; belongs to the military aerodrome, and is soon to be lighted by electricity with much higher candle-power. 5. Kaditz, near Dresden: revolving electric light with two flashes in 9 seconds, 46 meters above ground, 250 millimeters focal distance, 250,000 candle-power; shows the aerodrome at Kaditz. 6. Eilvese, near Neustadt, in Hanover: wireless station; revolving electric light flashing every 4 seconds, 22 meters above ground, 300,000 candle-power; indicates the tower of the T. S. F. station. 7. Gotha: fixed electric light with Fresnel lens, 22 meters above ground, 30,000 candle-power; indicates by flashes the number of the station; belongs to the Gotha carriage factory. 8. Grosser Feldberg, in the Taunus Mountains: fixed electric light, 910 meters above sea level, 800,000 candle-power, which will be raised much higher; was to be opened in April. 9. Johannisthal, near Berlin: fixed electric light with Fresnel lens, 25 meters above ground, 30,000 candle-power, indicates by flashes the number of the station; only used when required. 10. Königsberg: fixed acetylene flash light with Fresnel lens, 15 meters above ground, 1,300 candle-power; belongs to the military authorities, and indicates the shed for dirigibles. 11. Liegnitz: fixed electric light with Fresnel lens, 30 meters above ground, 8,500 candle-power; flashes give the number of the station; belongs to the military authorities, and indicates the shed for dirigibles. 12. Lindenberg, near Berlin: Morse beacon of nine lamps with metal filaments having together 3,600 candle-power, 130 meters above sea level; gives by flashes the letter L, at the Lindenberg Meteorological Observatory. 13. Metz: fixed acetylene flash light, Fresnel lens, 30 meters above ground, 1,200 candle-power; belongs to the military authorities, and indicates the dirigible shed. 14. Nauen: wireless station; Morse beacon with filament lamp of 1,000 candle-power, 180 meters above ground; gives letter N in flashes; shows large tower of the T. S. F. 15. Posen: fixed acetylene flash light, Fresnel lens, 15 meters above ground, 1,800 candle-power; belongs to the military authorities, and is on the field for maneuvers. 16. Posen: fixed electric light, Fresnel lens, 30 meters above ground, 8,500 candle-power; flashes give number of the station; belongs to the military authorities, is at the Wimarg shed for dirigibles. 17. Berlin, at Reinickendorf, fixed electric flash light, Fresnel lens, 30 meters above ground, 1,200 candle-power; belongs to the military authorities. 18. Schleissheim, near Munich: fixed flash light, 2,500 candle-power, can be raised to 30 meters above ground; belongs to the military authorities. 19. Strasburg: fixed acetylene light, Fresnel lens, 2,500 candle-power; flashes give number of station; at the aerodrome, and belongs to the military authorities. 20. Tegel, near Berlin: revolving acetylene flash light, 50 meters above sea level, 150 millimeters focal distance, 2,000 candle-power; belongs to the Second Battalion of the Aviation Corps. 21. Weimar: revolving electric flash light, 15 meters above the aerodrome, 27,200,000 candle-power; placed at the disposal of the Aviation Society of Weimar by its owner, the Carl Zeiss Company of Jena; works when required.

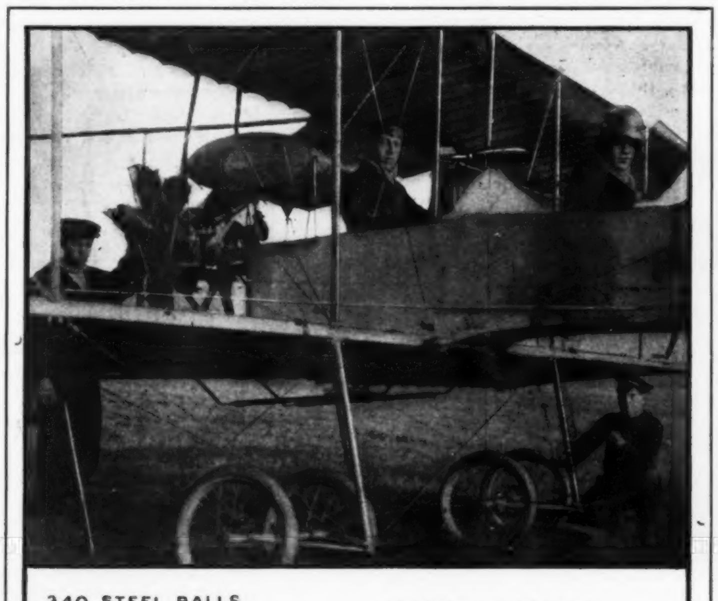
An Aeroplane Bomb That Explodes Only on Striking the Ground

The new Marten-Hale aeroplane bomb, recently tested in England, has a very simple priming mechanism so that it can be carried in a magazine on board an aeroplane without danger of accidental explosion. Should a bomb be hit while the aeroplane is in flight, or in case the aeroplane descended violently to the ground, by accident or otherwise, it is impossible for an explosion to take place. The bomb can explode only upon making a certain fall through the air and then striking the ground or other obstacle.

At the top the bomb has a tail piece *C*, rotatable by the air vanes. The detonator holder *D* is held up away from the main charge by means of its collar, and ball-bearing *G* held in place by the projecting end of a screw releasing spindle *H*. When the bomb drops and the spindle rotates, through the action of the vanes, it is screwed up until the projection moves away from the steel balls and allows them to fall inward, thus releasing the collar and the detonator. But the detonator still remains off the charge through the spring. When the bomb hits the ground, the detonator falls down on the charge and fires it, exploding the bomb in the customary way. Such bombs can be dropped simply by hand from the aeroplane or fired by a spring gun.

We illustrate a bomb of the shrapnel type, which has a total weight of 20 pounds and carries an explosive charge of about four pounds of trinitrotoluol. It has 340 steel balls, which weigh 5 pounds 12 ounces.

A drop through at least 200 feet in the air is needed in order to cause the rotation of the tail end sufficient to give the release and arm the bomb as we have just seen, and as the firing mechanism is very sensitive, it gives an explosion upon the least impact, even on water, mud, snow or the envelope of an airship. The angle of incidence can be as low as five degrees, as it is found. It is found that when dropped in any position from the aeroplane or at any speed of flight, the projectile soon takes the vertical position in falling, so as to hit the ground quite straight and end-on, and there is no tendency to somersaulting or wabbling in the air.



An aeroplane bomb that explodes only when it hits the ground.

Electric Mine Gas Detectors*

Different Devices that Have Been Used or Suggested to Test for Gas with an Electric Lamp

By Sydney F. Walker

The ordinary oil-burning safety lamp performs a double office in coal mines. It furnishes light, and it denotes the presence of firedamp. Although the portable electric miner's lamp will not detect methane, it is safer than the ordinary gauze safety lamp; it is not so easily extinguished, and it furnishes considerably more light. The fact that the electric lamp will not detect gas is a disadvantage; nevertheless that has not prevented its adoption. In British mines some years back portable electric lamps were very common, although not as strong nor as light as the Hirsch and Hubbell lamps; but at Murton colliery, Durham, England, some 2,000 Sussmann portable electric lamps have been in use for about fifteen years. Since the series of explosions that have occurred in coal mines in the United Kingdom within the last five or six years, several of which have been suspected to be caused by the old form of safety lamp, there has been a strong tendency toward the use of electric lamps. The difficulty of the detection of gas is met by the provision of a certain number of safety lamps, by which gas can be detected. Firemen carry an electric lamp, and an oil-burning lamp for testing.

The essential feature which provides the safety of the electric lamp, the inclosure of the heated filament within a globe from which the air has been exhausted, the globe being protected by a stout glass similar to those used in the oil-burning safety lamps, precludes the filament itself being used in any way as an indicator of gas. In the electric lamps which have passed the Home Office, and which were awarded prizes in a competition which took place two years ago, every effort is made to cut off the current from the filament in case of any accident happening to the lamp. In the best of the lamps the incandescent globe itself is placed between two springs, one of which makes connection with the battery; and anything which would cause a breakage of the lamp globe immediately severs the connection, long before the gas could find its way to the filament.

Anything, therefore, which indicates gas must be external to the lamp globe, and several attempts have been made to work out something of the kind. Up to the present there is no satisfactory electric gas detector upon the market. Inventors, so far, have worked along two lines. One inventor produced a gas detector that could be used by firemen, in which the difference in the rate of the diffusion of methane and ordinary atmospheric air, through a porous diaphragm, was made to operate an electric contact, closing an electric circuit and lighting a small lamp that was colored red. As far as the writer is aware, this apparatus never went beyond the testing stage; but with the enormous developments that have taken place in connection with electric lamps it is well worth any inventor's while to take up the subject on those lines. Another apparatus, designed upon something of the same lines, but smaller and more portable, is arranged to be either carried in the pocket or attached to a lamp. A U tube in which is a mercury column indicates the percentage of gas, and the instrument, it is stated, can be employed to detect CH_4 or CO_2.

Turquand's apparatus for testing for gas in mines consists of the U tube shown in Fig. 1, the ends of which pass into slots in a metal block. The ends of the U tube are open, but the slots are closed by porous stoppers *a*, thus leaving a space *b* between each end of the U tube and each porous stopper. In one space a palladium wire *c* is fixed, through which a current can be passed, either from the battery attached to the lamp or from an independent battery. In the other space an absorbent has to be placed, so as to discriminate between CH_4 and CO_2. The U tube has a very fine bore, and in it is what the inventor terms a thread of mercury. Normally the mercury will be at the same level in the two legs. When a gas having catalytic value that will act upon the hot palladium wire in the well-known manner, passes into the catalytic space, heat is liberated, and the thread of the mercury is pushed down one leg and up the other. The U tubes are graduated, presumably in units, showing the percentage of gas. Fig. 2 shows the connections for supplying current when the apparatus is in use.

Almost all other methods that have been employed depended upon the contact action between firedamp and a platinum wire, that is, when a combustible gas is brought in contact with a platinum wire and causes it to glow. The earliest apparatus, that of Prof. Diveing, employed two platinum spirals, glowing equally, one in atmospheric air, and the other in the gaseous atmosphere to be tested. The percentage of gas was found by comparing the light given by the two spirals on a photometer scale. It was used some in English mines, but only by managers and others who possessed the necessary skill and patience. Sir Joseph Swan, soon after his incandescent lamp was perfected, introduced an attachment in which a column of mercury, which expanded under the heat liberated by the catalysis of

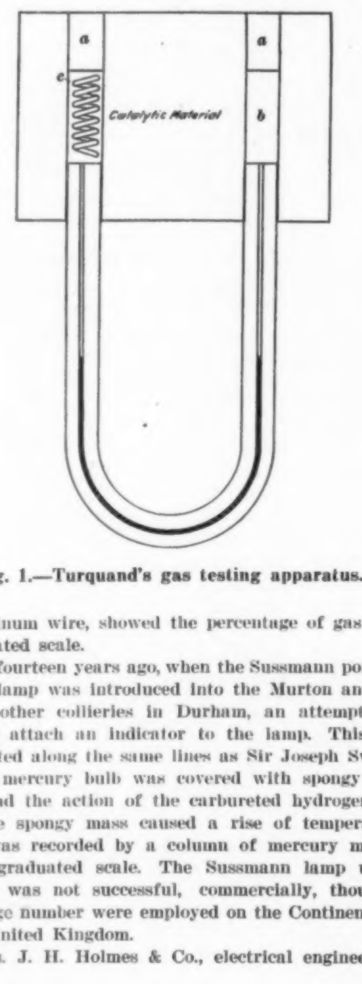


Fig. 1.—Turquand's gas testing apparatus.

the platinum wire, showed the percentage of gas upon a graduated scale.

Some fourteen years ago, when the Sussmann portable electric lamp was introduced into the Murton and one or two other collieries in Durham, an attempt was made to attach an indicator to the lamp. This was constructed along the same lines as Sir Joseph Swan's, but the mercury bulb was covered with spongy platinum, and the action of the carbureted hydrogen gas upon the spongy mass caused a rise of temperature, which was recorded by a column of mercury moving over a graduated scale. The Sussmann lamp unfortunately was not successful, commercially, though a very large number were employed on the Continent and in the United Kingdom.

Messrs. J. H. Holmes & Co., electrical engineers of

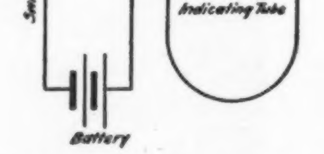


Fig. 2.—Electrical connections of the gas detector.

Newcastle, brought out a gas detector about four years ago that was intended to be fixed at different places in the mine, and to ring a bell in the overman's cabin, or on the surface, when gas appeared in certain prearranged quantities in the neighborhood of the apparatus. In this apparatus also, a column of mercury moving over a graduated scale closed an electric contact; the bulb of the thermometer, as it was practically, being inclosed in spongy platinum. About three years ago the problem was taken up by Mr. George Ralph, and the writer, on behalf of Sir William Garforth. In Mr. Ralph's apparatus a simple arrangement known as the differential galvanometer was employed. The galvanometer is an apparatus in which a current passing in a coil of wire surrounding a magnetic needle causes a deflection of the needle, bearing a certain relation to the current. In the differential galvanometer there are two such coils acting in opposite directions upon the needle. Under ordinary conditions the needle is stationary; but if the current passing in one coil is greater than that in the other, the needle deflects. The current in one coil may be lessened by an increase in the electrical resistance of the circuit in which that coil is included, and this was the method adopted by Mr. Ralph. One of the coils of the differential galvanometer included in this circuit a platinum wire which was arranged to be exposed to the gas, protected by the usual gauze. When gas was present, catalytic action took place in the platinum wire, the resistance of the wire increased in a certain ratio to the amount of gas present, and the needle deflected. Variations of Mr. Ralph's method included an apparatus for extinguishing the light given by the lamp, for putting a buzzer in action and other arrangements. Unfortunately all the experiments mentioned, with the exception of those of Prof. Liveing and Sir Joseph Swan, were made with ordinary illuminating gas. It was supposed by all those who were working at the problem that town gas and mine gas were the same. In the United Kingdom, however, town gas contains about 40 per cent of hydrogen and only about 35 per cent of methane; while mine gas consists almost entirely of methane. Hydrogen gas has a very much more energetic catalytic action upon a glowing platinum wire or spongy platinum than methane; and it was found that the apparatus that gave excellent results with town gas, showing a fraction of 1 per cent gas, gave absolutely no indications when taken into a colliery and tested in positions where it was known that methane was present.

The apparatus constructed for Sir William Garforth was on totally different lines. Mr. Garforth had invented an apparatus for testing for gas with the ordinary safety lamp, in which a rubber bulb having a strong metal nozzle was used. In the base of the oil-burning safety lamp was a tube and a self-closing valve. When testing for gas the bulb was placed in one of the cavities in the roof where gas was suspected, squeezed in the usual way, a bulb full of the atmosphere taken, a finger placed over the nozzle, the lamp taken to a safe position, the nozzle pushed through the base of the lamp, opening the valve in the process, and the gas in the bulb was squirted over the flame in the lamp. It will be seen that this method enabled tests of gas to be taken easily and quickly under conditions where it was almost impossible by the ordinary method, of nearly extinguishing the light, and pushing the lamp up into a cavity in the roof.

In the apparatus there were one or more small glass tubes fixed inside of the usual protecting glass tube of the portable electric lamp. Each of the small glass tubes held a platinum wire of a gage varying with the quantity of gas that was suspected. At the entrance to each tube was a self-closing valve that was pushed open by the nozzle of the rubber ball described above. It switched on the current to the platinum wire, and it opened the way for the gas to pass to the wire. In using the apparatus the nozzle of the bulb was first pushed into the aperture, opening the valve, and time was given to allow the platinum wire to come to its proper temperature. The gas was then squeezed from the bulb over the wire. The little test tubes were arranged to be easily and quickly replaced, and the platinum wire was protected by gauze in a similar manner, though on a small scale, to that in which the ordinary oil-burning safety lamp is protected.

The writer, with his client's full knowledge, worked with ordinary town illuminating gas, and with that he produced detector tubes of sufficient sensitiveness to show the presence of 0.5 per cent gas. It was his intention to have gone on from that point with pure methane, and he proposed to have used the metal palladium, which is more sensitive than platinum; and the measurements which he made upon an experimental tube in which a palladium wire was employed showed that there was every probability of obtaining as great success with palladium and methane as he had obtained with platinum and ordinary town gas, but his client would not go on. In the apparatus worked out for Sir William Garforth it was arranged to carry one, two, or three tubes in any lamp, and there was a range of tubes with corresponding platinum wires, all of the same length, but of varying section, so that tests from 0.5 per cent up to 5 per cent could be obtained. The method to be adopted was, the lamp man would carry tubes in his pocket and would make tests downward. He would put in the coarser tube first, then tubes with finer wires, and so on.

* From the *Colliery Engineer*.

Navigation Without Logarithms*

By Walter D. Robinson

Capt. Guyou of the French navy, a mathematician of note, author of valuable works dealing with the problems of navigation, and member of various learned societies, has devoted part of his time since his retirement to producing tables from which a "line of position" (Sumner line) can be worked and the ship's position thereon approximately determined with the least labor and in shortest time.

The tables are preceded by a condensed explanation for the benefit of those who wish to understand their mathematical development; but the many practical and efficient navigators who bother little with theory will be interested to know what Capt. Guyou does, without having to concern themselves as to how he does it.

Gird up your imagination and conceive the world and the heavenly bodies as standing still; suppose, further, that your ship is connected with a heavenly body not directly overhead—the sun, for instance—by a steel rod having a universal bearing where attached to the ship and another where attached to the sun. Start up your engine and let the wheel alone! The ship will be so controlled by the rod that she must describe an enormous circle on the face of the waters, having for its center that point on the earth's surface at which the sun is then in the zenith. Meanwhile, the rod describes an enormous cone with the sun at the apex, and when we consider that the sun's altitude, or height, is measured by the angle inclosed between the rod and the base of the cone (roughly), we can realize that an observer on board, taking the sun's height with a sextant at frequent intervals, will get the same height all the way around the circle.

The foregoing must be qualified in practice because the world does not stand still and the ship is not going to sail on a circular course; true, she is on the circumference at the moment of observation, but she may be crossing it at any angle because the position of the center of the circle and the direction in which the circumference trends depend upon the sun and not upon the ship.

If the ship be at rest, the observed altitude of the sun will change continually from hour to hour because of the apparent motion of the sun in his diurnal course. If the ship be in motion, the observed altitude of the sun will likewise change from hour to hour, not only because of the sun's apparent diurnal motion, but also, although by a comparatively small amount, because of the fact that the ship is under way pursuing a certain course and making a certain rate of speed. It is evident that she may be considered to be crossing a circumference at any moment and that all sun observations *taken at that moment* from ships on different parts of that circumference will show the same altitude.

Two problems present themselves!

First: To find the circumference.

Second: To find the point at which the ship was crossing it when the observation was taken.

They have been dealt with in various ways. An able French admiral, Marcq de Saint-Hilaire, evolved an admirable solution by working out the distance from the dead-reckoning point—almost always more or less erroneous—to the circumference; his method may be outlined as follows: The navigator measures the height with a sextant, notes the time, then *calculates* the height he would have gotten at the dead-reckoning point at the moment of observation. If the two heights agree the dead reckoning may be accepted as correct, for it coincides with the circumference; this occurs but rarely; as a usual thing the dead-reckoning point falls several minutes (of distance) outside the circle or within it, two heights result, and the difference between them enables the navigator to work out the error in distance from dead reckoning to circumference. This solves the first problem!

The solution of the second is simpler, because the dead reckoning is sufficiently reliable to limit to a few sea-miles that portion of the circumference at some point in which the observation must have been taken. Since the circle is very large, this small portion of circumference may be accepted as a straight line. It is the navigator's "line of position" and the ship's crossing point thereon is closely approximated by the direction of the center of the circle from the dead-reckoning point, which direction, since the sun is the zenith of the circle's center, is rendered by the azimuth.

But this method, though far the most desirable theoretically, involves the danger of error, the time, labor, and irritation inseparable from an appalling array of logarithms—I rejoice that I am not called upon to express the sentiments with which a tired and hungry man in oil-skins regards logarithms—the calculation of height at the dead reckoning point calls for a half dozen, the azimuth for three or four more, and these operations are followed by an excursion into trigonometry to localize the result; which result, if you are an amateur, will doubtless be wrong, while, if a professional, you will not have tried it.

With Capt. Guyou's tables one enters with true height and declination in a page devoted to the approximate latitude and takes out two numbers, turns to a page devoted to the approximate hour-angle and takes out two more. With these numbers he does one small sum in addition and two in subtraction, then rules off the ship's position on the chart.

One can only admire the lofty unconcern with which Capt. Guyou juggles distances, especially as he juggles them accurately. One of his circles can inclose the greater part of a hemisphere, but he does not hesitate to slide it down until the dead-reckoning latitude coincides with the equator, where he performs his mathematical feat with the two heights before coolly sliding the circle back again. Of course the objection at once arises that the navigator would not have gotten the same observed and calculated heights on the equator that he did get in higher latitudes, but here Capt. Guyou's versatile resource comes into play, for the navigator *would* have gotten the same number of minutes of difference between the two heights (expressed in minutes of the respective latitudes). This difference, as we have seen above, yields the error in distance between dead reckoning and circumference, and from it, in connection with the azimuth, the position can be worked out.

But Capt. Guyou does not slide down to the equator merely in search of the above-mentioned error. He has another purpose and it is indeed ingeniously accomplished: we all know that the basis of navigation is the spherical triangle, and that three parts of it—two sides and one angle, for instance—must be known before it can be solved. But tables calling for the combination of three known quantities throughout the extent of 90 degrees of latitude and 360 degrees of longitude would be ponderous and impractical. With only two known quantities these objections do not obtain, but two known quantities do not suffice to solve the problem. In drawing up his tables Capt. Guyou has used three, of which the latitude is the third, and has employed a trigonometrical formula in which the required result is obtained by multiplying functions of the two other known quantities by the tangent of one half the complement of the third (the latitude). Since he has slid his circle down until the (dead reckoning) latitude coincides with the equator his latitude is 0 degree; the complement 90 degrees; and the tangent ½ 90 degrees = 1, which, as a multiplier, may be disregarded, thus reducing the known quantities which must be considered to two, and rendering the tables practicable.

Little knowledge of navigation is required in using them. One must understand reducing observed height to true and correcting the declination for the moment of observation. It is of course necessary to be familiar with the varieties of time used at sea. In figuring, one must know, and observe, the diffence between + and —.

These moderate requirements can be mastered in a few evenings, and practice may then be begun over an artificial horizon, or otherwise, for the tables include a page of directions which cover all cases, and can be blindly followed to a correct result. A general conception of the principles of navigation and the problems involved will come with practice and the necessity of thinking out one's mistakes, and, in a short time, a new hand should be able to work at sight with confidence and accuracy.

* "Nouvelles Tables de Navigation," Emile Guyou, Berger-Levrault, Editeurs, Paris. Review from *Science*.

Man's Chin

A Dynamical Basis for Physical and Psycho-Physiological Utilities.

To account for the presence of man's chin at least three different explanations have been brought forward and discussed: (1) That the chin has been evolved by sex selection for its æsthetic value; (2) that it was needful for the development of the genio-glossal muscle and speech; (3) that with man's erect posture the chin has been chiefly useful in affording room for important structures in the throat, and in protecting them during combat, etc. These explanations have so far met with very little acceptance.

A conception of the chin as a *dynamical* factor in both mastication and speech does not appear to have received attention. An engineer examining the dental mechanism as a type of machine new to him would, on finding there was a considerable bulk of constructional material projecting from the chief moving member, be nearly certain to ask—What does this do? The chin mass is situated at the outer end of the jaw lever, where its momentum is greatest. It is built up in the heavier material used in the general construction. There is another point, too, that one should not too readily dismiss as a mere coincidence. Every rotation movement of the mandible during its elevation or shutting has combined with it a movement—obliquely upward and backward—of translation. The combined movements are so directed that at some parts of the jaw the resultant velocity is less than would exist if either component were to act alone; and at about a point situated between the jaw angle and the condyle, the resultant velocity is so small that some observers mistakenly believed it to be nil. At the chin, on the other hand, the directions of the component movements are such that the resultant velocity reaches nearly its maximum acceleration.

My suggestion is not quite that the chin is simply man's masticating hammer; something rather less crude than a purely percussive function is conditioned by the momentum of the chin. No doubt the momentum of the chin may appear to be a very small contribution to the considerable muscular force often used in chewing. Yet on the teeth themselves many morphological details that have been preserved as distinct specific features are so small that we do not yet know what the particular utilities are that determined their shape and survival. Further, there is another peculiarity in the mandible movement that may have some significance in this connection. During a (supposable) uniform movement of rotation about the condyle as horizontal axis, the accompanying translation movement is not uniform, but relatively varied—slow or small in the beginning, quicker in the middle, and slower again toward the end of the condyle path. This is favorable to the normal *rhythmical* movement of the jaw by giving in some degree a pendulum-like character to its swing. And it so happens that the position of maximum velocity (and momentum) coincides with the position of greatest resistance and food-strain in chewing—that is, when the cutting-edges of the external blades of the lower cheek teeth are just about to pass their upper opponents in the inward-and-upward shearing thrust. The chin momentum operates most strongly just about the point where it is most useful in preserving the rhythmical movement of mastication, so as to render less necessary any *consciously* directed variation in the muscular effort put forth in any single chewing stroke.

Then, in the numerous smaller chewing movements for the finer reduction of food morsels, the chin mass (by both inertia and momentum) has at least some value as a "balance"; controlling and guiding the niceties of direction in the thrust. The utility of balance influences the construction of many man-made implements (pen- or brush-holder, razor handle, spear, etc.) in the use of which some precision is required; this feature in construction has usually been adopted, and has survived quite independently of any conscious or theoretical estimation of its special function. The obvious objection that animals manage the "niceties" of mastication without a chin could be met only by going more fully into the dynamics of the subject. This much at least can be stated here as being susceptible of proof—that as compared with the prognathous savage or the ape, the dental apparatus of modern civilized man is the "finer" machine, in so far as it is the better adapted for those shearing stresses by which tough foodstuffs are comminuted with economy of effort.

The above suggestion of "balancing" and "steadying" utilities can also be applied to the rapid and yet delicately controlled movements of the mandible in speech. The man who wrote a book on "The Speech of Monkeys" might possibly have had hope of more success in interpreting the "language" of these animals if only he could have subdued and steadied their jibberings and chatterings by providing them with good weighty chins.—From a letter to *Nature* by D. M. Shaw.

The Melting and Solidifying Points of Lava

An account is given in the *Proceedings* of the Mathematico-Physical Society Tokyo, by K. Fugi and T. Mizoguchi, of some investigations in relation to the above subject. By an apparatus designed to give simultaneously both the temperature and electrical conductivity of lava, a range of temperatures was obtained over which lava is melting and solidifying, on the assumption that the electrical conductivity of the molten lava increases proportionately with the decrease of viscosity. A curve in which current, representing conductivity, is plotted against temperature shows a point of inflection at about 1,130 deg. Cent., which the authors consider would correspond to the melting point of a crystalline substance. The values given of the specific resistance at various temperatures are, in the neighborhood of the melting point, somewhat less than that of sea water. The importance of this high conductivity in connection with its influence upon the propagation of Hertzian waves is pointed out. The results of the melting-point determinations are compared with observations made by one of the authors upon a lava stream from a volcano by means of a Holborn-Kurlbaum optical pyrometer. The results show that the optical pyrometer cannot be relied upon for such measurements.

Applications of the Coolidge X-Ray Tube*

Illustrating the Varied Subjects that are Within the Range of a Single, Simple Tube

By Dr. Wheeler P. Davey

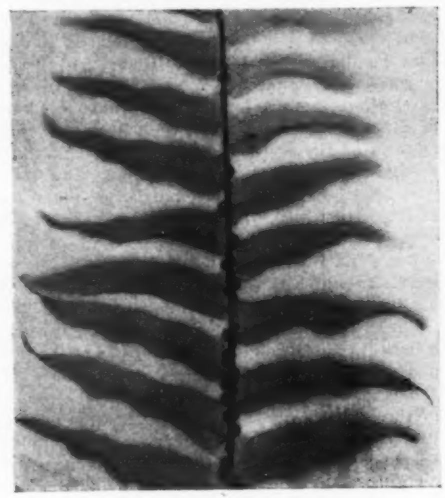
There have lately been published many very interesting radiographs of flowers, leaves and insects. Typical instances are shown by Pierre Goby, Hall-Edwards and others. These men have found it desirable in such work to use tubes in which the vacuum was widely different from that employed in ordinary radiographic work. For instance, in referring to a splendid radiograph of tulip blossoms, Hall-Edwards (Archives of the Roentgen ray, June, 1914), who is using tubes of the ordinary type (in this case a "Muller" with a Bauer regulator) notes that "it is rather dangerous to use new tubes for this purpose (although the best results can undoubtedly be obtained by them), for the reason that it is very easy to pass the boundary line and get a vacuum so low that it cannot be raised without re-exhausting the tube." Such difficulties, though they have not prevented securing beautiful radiographs, have doubtless kept this method of internal and structural photography from advancing as rapidly as it might otherwise have done.

The Coolidge X-ray tube[1] has proved itself to be a

* Reproduced from the *General Electric Review*.

[1] See *Physical Review*, December, 1913, or *General Electric Review*, February, 1914.

Fern bud and dandelion bud, illustrating wide latitude of type.

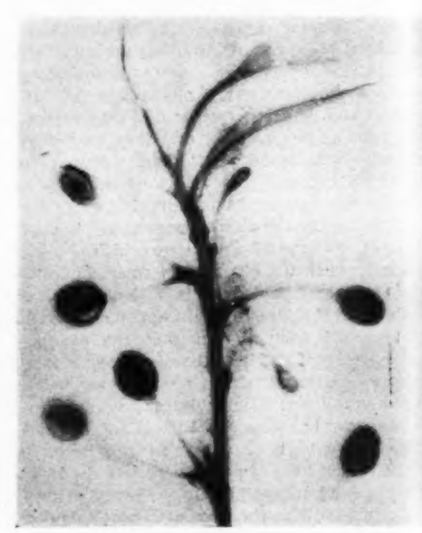


Fern leaf with colonies of bugs.

Cherry twigs, with young leaves, buds, and freshly opened flowers.

Cherry twigs with mature blossoms. Two blossoms have lost their petals.

Cherry twig. The cherry is starting to form around the pit.



Cherry twig. The cherries here shown are about half developed.

Golden-rod gall. The worm inside is alive, and was not injured.

Crayfish. This subject differs from the tadpole, in that the bony structure is on the outside.

Ingersoll watch. Showing ease with which dense subjects can be examined.

efficient tool in the hands of the medical profession, and it occurred to the writer that it would prove equally valuable to botanists and biologists in connection with the study of plant and animal life.

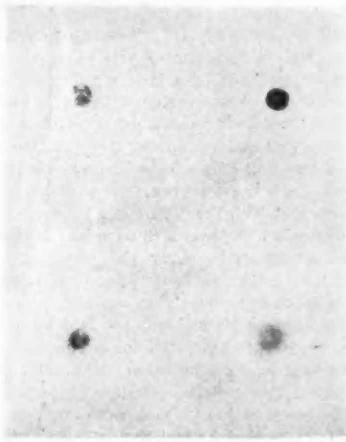
The main advantages in the use of the Coolidge tube are (1) the independence of the quantity and the penetrating ability of the rays produced, (2) the ease and rapidity with which the quantity and penetration of the rays may be regulated, and (3) the fact that when the tube is once adjusted to the requirements of the operator it needs no further attention. To bring the tube to any desired adjustment, the operator pulls a handle which regulates the current through the tube, thus determining definitely the quantity of X-rays produced. He then adjusts the voltage across the tube until the penetration is of the desired degree. These adjustments are rapid and require the minimum of technical skill.

To illustrate this, the writer took a tube at random and took a number of radiographs of various botanical specimens. It was at once found that, when the proper penetration and exposure had been determined, the radiographs could be duplicated time after time with absolute precision. Then biological specimens were tried, and finally radiographs were taken of dense objects, such as fuse plugs and Ingersoll watches. As in the case of the botanical specimens, all of these radiographs could be accurately reproduced as often as desired.

The radiographs reproduced here were not chosen from the total number taken because of any novelty or excellence in the pictures themselves, but rather because they show what a wide range of work can be done with a single Coolidge tube, and because they suggest that the Coolidge tube is destined to become a precision instrument of value to the botanist, biologist and mineralogist as well as to the physicist and the physician.

None of the pictures shown here have been retouched or altered in any way.

Tadpoles. Note growth of the intestines, and ossification of vertebrae.



The substances most commonly used to imitate diamonds are fused oxide of aluminium, quartz, and lead glass. The figure shows a radiograph of these three as contrasted with a diamond of the same size. In the order of transparency to X-rays they are: diamond, fused oxide of aluminium, quartz, lead glass.

Egg, nearly hatched.

Four-legged chicken. Five hours old. Showing curious formation of the skeleton.

Tadpole. Magnified three and one half diameters. Note articles of food in the intestines.

A young frog. Ossification of the bones nearly complete.

Alcohol as a Motorcar Fuel

In some experiments recently made in England excellent results were obtained with alcohol as a fuel, the only change to the motor being an alteration of the carbureter jet. It is well known that many internal combustion motors designed for gasoline will run quite well when alcohol is used, but if the latter fuel was to be used exclusively, undoubtedly some increase in compression over that commonly used would be provided for, and the motor used in this test evidently had a fairly high compression.

The car was a 15-20 horse-power, with four 80 millimeter by 120 millimeter cylinders, and weighing 23¼ hundredweight approximately, the total running weight being 28¾ hundredweight approximately. The engine revolutions at 20 miles per hour were 903 per minute. The car was fitted with a Zenith carbureter, horizontal type, and beyond changing the jets between tests no other preparation for using the various fuels was made. The cubical contents of the compression space of a cylinder of the engine was 181.5 cubic centimeters, and the cubical contents of the volume swept by the piston was 603.18 cubic centimeters, giving a compression ratio of 4.3. The following fuels were used: Shell No. 2, benzol, commercial methylated spirit, containing the usual denaturants and 90 per cent of alcohol, and a mixture of equal parts of the two last fuels. All were purchased in the open market by the club. The trial was held upon Brooklands Track, and the weather was very hot. The following are the results of the tests:

Nominal speed, m.p.h.	Shell No. 2	Benzol.	Methylated spirit.	Equal parts methylated spirit and benzol.
20..........	34.83 m.p.g.	40.39 m.p.g.	23.29 m.p.g.	32.41 m.p.g.
35..........	26.54 m.p.g.	31.25 m.p.g.	16.69 m.p.g.	25.34 m.p.g.
All out......	42.26 m.p.h.	40.73 m.p.h.	40.83 m.p.h.	40.58 m.p.h.

The engine, on account of the hot weather, was always warm when started, and thus no difficulty was experienced in starting.

Commenting on these tests, the agents of the car used, remark: "The fact that the speed 'all out' on methylated spirits was comparable to the speeds obtained with other fuels seems to indicate that the use of denatured alcohol is merely a question of price, and that if this fuel were available in sufficiently large quantities at a sufficiently low price there are no serious obstacles in the way of its employment. We take it that these results may be of direct and immediate value as applied to the use of motor vehicles in many colonies and foreign countries. So far as Great Britain is concerned, the interest is in a sense academic, since the present price of methylated spirits is considerably higher than that of gasoline or benzol, largely owing to various restrictions in the manufacture and sale."

Heredity—I*

New Theories and Facts Relating to the History of Organic Beings

By Prof. William Bateson

Recognition of the significance of heredity is modern. The term itself in its scientific sense is no older than Herbert Spencer. Animals and plants are formed as pieces of living material split from the body of the parent organisms. Their powers and faculties are fixed in their physiological origin. They are the consequence of a genetic process, and yet it is only lately that this genetic process has become the subject of systematic research and experiment. The curiosity of naturalists has of course always been attracted to such problems; but that accurate knowlege of genetics is of paramount importance in any attempt to understand the nature of living things has only been realized quite lately, even by naturalists, and with casual exceptions the laity still know nothing of the matter. Historians debate the past of the human species, and statesmen order its present or profess to guide its future as if the animal man, the unit of their calculations, with his vast diversity of powers, were a homogeneous material, which can be multiplied like shot.

The reason for this neglect lies in ignorance and misunderstanding of the nature of variation; for not until the fact of congenital diversity is grasped, with all that it imports, does knowledge of the system of hereditary transmission stand out as a primary necessity in the construction of any theory of evolution, or any scheme of human polity.

The first full perception of the significance of variation we owe to Darwin. The present generation of evolutionists realizes perhaps more fully than did the scientific world in the last century that the theory of evolution had occupied the thoughts of many and found acceptance with not a few before ever the "origin" appeared. We have come also to the conviction that the principle of natural selection cannot have been the chief factor in delimiting the species of animals and plants, such as we now with fuller knowledge see them actually to be. We are even more skeptical as to the validity of that appeal to changes in the conditions of life as direct causes of modification, upon which latterly at all events Darwin laid much emphasis. But that he was the first to provide a body of fact demonstrating the variability of living things, whatever be its causation, can never be questioned.

There are some older collections of evidence, chiefly the work of the French school, especially of Godron[1]—and I would mention also the almost forgotten essay of Wollaston[2]—these however are only fragments in comparison. Darwin regarded variability as a property inherent in living things, and eventually we must consider whether this conception is well founded; but postponing that inquiry for the present, we may declare that with him began a general recognition of variation as a phenomenon widely occurring in nature.

If a population consists of members which are not alike but differentiated, how will their characteristics be distributed among their offspring? This is the problem which the modern student of heredity sets out to investigate. Formerly it was hoped that by the simple inspection of embryological processes the modes of heredity might be ascertained, the actual mechanism by which the offspring is formed from the body of the parent. In that endeavor a noble pile of evidence has been accumulated. All that can be made visible by existing methods has been seen, but we come little if at all nearer to the central mystery. We see nothing that we can analyze further—nothing that can be translated into terms less inscrutable than the physiological events themselves. Not only does embryology give no direct aid, but the failure of cytology is, so far as I can judge, equally complete. The chromosomes of nearly related creatures may be utterly different both in number, size, and form. Only one piece of evidence encourages the old hope that a connection might be traceable between the visible characteristics of the body and those of the chromosomes. I refer of course to the accessory chromosome, which in many animals distinguishes the spermatozoon about to form a female in fertilization. Even it however cannot be claimed as the cause of sexual differentiation, for it may be paired in forms closely allied to those in which it is unpaired or accessory. The distinction may be present or wanting, like any other secondary sexual character. Indeed, so long as no one can show consistent distinctions between the cytological characters of somatic tissues in the same individual we can scarcely expect to perceive such distinctions between the chromosomes of the various types.

For these methods of attack we now substitute another, less ambitious, perhaps, because less comprehensive, but not less direct. If we cannot see how a fowl by its egg and its sperm gives rise to a chicken or how a sweet pea from its ovule and its pollen grain produces another sweet pea, we at least can watch the system by which the differences between the various kinds of fowls or between the various kinds of sweet peas are distributed among the offspring. By thus breaking the main problem up into its parts we give ourselves fresh chances. This analytical study we call mendelian because Mendel was the first to apply it. To be sure, he did not approach the problem by any such line of reasoning as I have sketched. His object was to determine the genetic definiteness of species; but though in his writings he makes no mention of inheritance it is clear that he had the extension in view. By cross-breeding he combined the characters of varieties in mongrel individuals and set himself to see how these characters would be distributed among the individuals of subsequent generations. Until he began this analysis nothing but the vaguest answers to such a question had been attempted. The existence of any orderly system of descent was never even suspected. In their manifold complexity human characteristics seemed to follow no obvious system, and the fact was taken as a fair sample of the working of heredity.

Misconception was especially brought in by describing descent in terms of "blood." The common speech uses expressions such as consanguinity, pure-blooded, half-blood, and the like, which call up a misleading picture to the mind. Blood is in some respects a fluid, and thus it is supposed that this fluid can be both quantitatively and qualitatively diluted with other bloods, just as treacle can be diluted with water. Blood in primitive physiology being the peculiar vehicle of life, at once its essence and its corporeal abode, these ideas of dilution and compounding of characters in the commingling of bloods inevitably suggest that the ingredients of the mixture once combined are inseparable, that they can be brought together in any relative amounts, and in short that in heredity we are concerned mainly with a quantitative problem. Truer notions of genetic physiology are given by the Hebrew expression "seed." If we speak of a man as "of the blood-royal" we think at once of plebeian dilution, and we wonder how much of the royal fluid is likely to be "in his veins"; but if we say he is "of the seed of Abraham" we feel something of the permanence and indestructibility of that germ which can be divided and scattered among all nations, but remains recognizable in type and characteristics after 4,000 years.

I knew a breeder who had a chest containing bottles of colored liquids by which he used to illustrate the relationships of his dogs, pouring from one to another and titrating them quantitatively to illustrate their pedigrees. Galton was beset by the same kind of mistake when he promulgated his "Law of Ancestral Heredity." With modern research all this has been cleared away. The allotment of characteristics among offspring is not accomplished by the exudation of drops of a tincture representing the sum of the characteristics of the parent organism, but by a process of *cell-division*, in which numbers of these characters, or rather the elements upon which they depend, are sorted out among the resulting germ-cells in an orderly fashion. What these elements, or *factors* as we call them, are we do not know. That they are in some way directly transmitted by the material of the ovum and of the spermatozoon is obvious, but it seems to me unlikely that they are in any simple or literal sense material particles. I suspect rather that their properties depend on some phenomenon of arrangement. However that may be, analytical breeding proves that it is according to the distribution of these genetic factors, to use a non-committal term, that the characters of the offspring are decided. The first business of experimental genetics is to determine their number and interactions, and then to make an analysis of the various types of life.

Now the ordinary genealogical trees, such as those which the stud-books provide in the case of the domestic animals, or the Heralds' College provides in the case of man, tell nothing of all this. Such methods of depicting descent cannot even show the one thing they are devised to show—purity of "blood." For at last we know the physiological meaning of that expression. An organism is pure-bred when it has been formed by the union in fertilization of two germ-cells which are alike in the factors they bear; and since the factors for the several characteristics are independent of each other, this question of purity must be separately considered for each of them. A man, for example, may be pure-bred in respect of his musical ability and cross-bred in respect of the color of his eyes or the shape of his mouth. Though we know nothing of the essential nature of these factors, we know a good deal of their powers. They may confer height, color, shape, instincts, powers both of mind and body; indeed, so many of the attributes which animals and plants possess that we feel justified in the expectation that with continued analysis they will be proved to be responsible for most if not all of the differences by which the varying individuals of any species are distinguished from each other. I will not assert that the greater differences which characterize distinct species are due generally to such independent factors, but that is the conclusion to which the available evidence points. All this is now so well understood, and has been so often demonstrated and expounded, that details of evidence are now superfluous.

But for the benefit of those who are unfamiliar with such work let me briefly epitomize its main features and consequences. Since genetic factors are definite things, either present in or absent from any germ-cell, the individual may be either "pure-bred" for any particular factor, or its absence, if he is constituted by the union of two germ-cells both possessing or both destitute of that factor. If the individual is thus pure, all his germ-cells will in that respect be identical, for they are simply bits of the similar germ-cells which united in fertilization to produce the parent organism. We thus reach the essential principle, that an organism cannot pass on to offspring a factor which it did not itself receive in fertilization. Parents, therefore, which are both destitute of a given factor can only produce offspring equally destitute of it; and, on the contrary, parents both pure-bred for the presence of a factor produce offspring equally pure-bred for its presence. Whereas the germ-cells of the pure-bred are all alike, those of the cross-bred, which results from the union of dissimilar germ-cells, are mixed in character. Each positive factor segregates from its negative opposite, so that some germ-cells carry the factor and some do not. Once the factors have been identified by their effects, the average composition of the several kinds of families formed from the various matings can be predicted.

Only those who have themselves witnessed the fixed operations of these simple rules can feel their full significance. We come to look behind the simulacrum of the individual body and we endeavor to disintegrate its features into the genetic elements by whose union the body was formed. Set out in cold general phrases such discoveries may seem remote from ordinary life. Become familiar with them and you will find your outlook on the world has changed. Watch the effects of segregation among the living things with which you have to do—plants, fowls, dogs, horses, that mixed concourse of humanity we call the English race, your friends' children, your own children, yourself—and however firmly imagination be restrained to the bounds of the known and the proved, you will feel something of that range of insight into nature which mendelism has begun to give. The question is often asked whether there are not also in operation systems of descent quite other than those contemplated by the mendelian rules. I myself have expected such discoveries, but hitherto none have been plainly demonstrated. It is true we are often puzzled by the failure of a parental type to reappear in its completeness after a cross—the merino sheep or the fantail pigeon, for example. These exceptions may still be plausibly ascribed to the interference of a multitude of factors, a suggestion not easy to disprove; though it seems to me equally likely that segregation has been in reality imperfect. Of the descent of quantitative characters we still know practically nothing. These and hosts of difficult cases remain almost untouched. In particular the discovery of E. Baur, and the evidence of Winkler in regard to his "graft hybrids," both showing that the sub-epidermal layer of a plant—the layer from which the germ-cells are derived—may bear exclusively the characters of a part only of the soma, give hints of curious complications, and suggest that in plants at least the inter-

* An address delivered at Melbourne and Sydney, Australia, before the British Association for the Advancement of Science.

[1] "De l'Espèce et des Races dans les Êtres Organisés," 1859.

[2] "On the Variation of Species," 1856.

relations between soma and gamete may be far less simple than we have supposed. Nevertheless, speaking generally, we see nothing to indicate that qualitative characters descend, whether in plants or animals, according to systems which are incapable of factorial representation.

The body of evidence accumulated by this method of analysis is now very large, and is still growing fast by the labors of many workers. Progress is also beginning along many novel and curious lines. The details are too technical for inclusion here. Suffice it to say that not only have we proof that segregation affects a vast range of characteristics, but in the course of our analysis, phenomena of most unexpected kinds have been encountered. Some of these things twenty years ago must have seemed inconceivable. For example, the two sets of sex organs, male and female of the same plant, may not be carrying the same characteristics; in some animals characteristics, quite independent of sex, may be distributed solely or predominantly to one sex; in certain species the male may be breeding true to its own type, while the female is permanently mongrel, throwing off eggs of a distinct variety in addition to those of its own type; characteristics, essentially independent, may be associated in special combinations which are largely retained in the next generation, so that among the grandchildren there is numerical preponderance of those combinations which existed in the grandparents—a discovery which introduces us to a new phenomenon of polarity in the organism.

We are accustomed to the fact that the fertilized egg has a polarity, a front and hind end for example; but we have now to recognize that it, or the primitive germinal cells formed from it, may have another polarity shown in the groupings of the parental elements. I am entirely sceptical as to the occurrence of segregation solely in the maturation of the germ-cells,[3] preferring at present to regard it as a special case of that patch-work condition we see in so many plants. These mosaics may break up, emitting bud-sports at various cell-divisions, and I suspect that the great regularity seen in the F_2 ratios of the cereals, for example, is a consequence of very late segregation, whereas the excessive irregularity found in other cases may be taken to indicate that segregation can happen at earlier stages of differentiation.

The paradoxical descent of color-blindness and other sex-limited conditions—formerly regarded as an inscrutable caprice of nature—has been represented with approximate correctness, and we already know something as to the way, or, perhaps, I should say ways, in which the determination of sex is accomplished in some of the forms of life—though, I hasten to add, we have no inkling as to any method by which that determination may be influenced or directed. It is obvious that such discoveries have bearings on most of the problems, whether theoretical or practical, in which animals and plants are concerned. Permanence or change of type, perfection of type, purity or mixture of race, "racial development," the succession of forms, from being vague phrases expressing matters of degree, are now seen to be capable of acquiring physiological meanings, already to some extent assigned with precision. For the naturalist—and it is to him that I am especially addressing myself to-day—these things are chiefly significant as relating to the history of organic beings—the Theory of Evolution, to use our modern name. They have, as I shall endeavor to show in my second address to be given in Sydney, an immediate reference to the conduct of human society.

I suppose that everyone is familiar in outline with the theory of the Origin of Species which Darwin promulgated. Through the last fifty years this theme of the natural selection of favored races has been developed and expounded in writings innumerable. Favored races certainly can replace others. The argument is sound, but we are doubtful of its value. For us, that debate stands adjourned. We go to Darwin for his incomparable collection of facts. We would fain emulate his scholarship, his width and his power of exposition, but to us he speaks no more with philosophical authority. We read his scheme of evolution as we would those of Lucretius or of Lamarck, delighting in their simplicity and their courage. The practical and experimental study of variation and heredity has not merely opened a new field; it has given a new point of view and new standards of criticism. Naturalists may still be found expounding teleological systems[4] which would have delighted Dr. Pangloss himself, but at the present time few are misled. The student of genetics knows that the time for the development of theory is not yet. He would rather stick to the seed-pan and the incubator.

In face of what we now know of the distribution of variability in nature the scope claimed for natural selection in determining the fixity of species must be greatly reduced. The doctrine of the survival of the fittest is undeniable so long as it is applied to the organism as a whole, but to attempt by this principle to find value in all definiteness of parts and functions, and in the name of science to see fitness everywhere, is mere eighteenth century optimism. Yet it was in application to the parts, to the details of specific difference, to the spots on the peacock's tail, to the coloring of an orchid flower, and hosts of such examples, that the potency of natural selection was urged with the strongest emphasis. Shorn of these pretensions the doctrine of the survival of favored races is a truism, helping scarcely at all to account for the diversity of species. Tolerance plays almost as considerable a part. By these admissions almost the last shred of that teleological fustian with which Victorian philosophy loved to clothe the theory of evolution is destroyed. Those who would proclaim that whatever is is right will be wise henceforth to base this faith frankly on the impregnable rock of superstition and to abstain from direct appeals to natural fact.

My predecessor said last year that in physics the age is one of rapid progress and profound scepticism. In at least as high a degree this is true of biology, and as a chief characteristic of modern evolutionary thought we must confess also to a deep but irksome humility in presence of great vital problems. Every theory of evolution must be such as to accord with the facts of physics and chemistry, a primary necessity to which our predecessors paid small heed. For them the unknown was a rich mine of possibilities on which they could freely draw. For us it is rather an impenetrable mountain out of which the truth can be chipped in rare and isolated fragments. Of the physics and chemistry of life we know next to nothing. Somehow the characters of living things are bound up in properties of colloids, and are largely determined by the chemical powers of enzymes, but the study of these classes of matter has only just begun. Living things are found by a simple experiment to have powers undreamt of, and who knows what may be behind?

Naturally we turn aside from generalities. It is no time to discuss the origin of the mollusca or of dicotyledons, while we are not even sure how it came to pass that *Primula obconica* has in twenty-five years produced its abundant new forms almost under our eyes. Knowledge of heredity has so reacted on our conceptions of variation that very competent men are even denying that variation in the old sense is a genuine occurrence at all. Variation is postulated as the basis of all evolutionary change. Do we then as a matter of fact find in the world about us variations occurring of such a kind as to warrant faith in a contemporary progressive evolution? Till lately most of us would have said "yes" without misgiving. We should have pointed, as Darwin did, to the immense range of diversity seen in many wild species, so commonly that the difficulty is to define the types themselves. Still more conclusive seemed the profusion of forms in the various domesticated animals and plants, most of them incapable of existing even for a generation in the wild state, and therefore fixed unquestionably by human selection. These, at least, for certain, are new forms, often distinct enough to pass the species, which have arisen by variation. But when analysis is applied to this mass of variation the matter wears a different aspect. Closely examined, what is the "variability" of wild species? What is the natural fact which is denoted by the statement that a given species exhibits much variation? Generally one of two things: either that the individuals collected in one locality differ among themselves; or perhaps more often that samples from separate localities differ from each other. As direct evidence of variation it is clearly to the first of these phenomena that we must have recourse—the heterogeneity of a population breeding together in one area. This heterogeneity may be in any degree, ranging from slight differences that systematists would disregard, to a complex variability such as we find in some moths, where there is an abundance of varieties so distinct that many would be classified as specific forms but for the fact that all are freely breeding together. Naturalists formerly supposed that any of these varieties might be bred from any of the others. Just as the reader of novels is prepared to find that any kind of parents might have any kind of children in the course of the story, so was the evolutionist ready to believe that any pair of moths might produce any of the varieties included in the species. Genetic analysis has disposed of all these mistakes. We have no longer the smallest doubt that in all these examples the varieties stand in a regular descending order, and that they are simply terms in a series of combinations of factors separately transmitted, of which each may be present or absent.

The appearance of contemporary variability proves to be an illusion. Variation from step to step in the series must occur either by the addition or by the loss of a factor. Now, of the origin of new forms *by loss* there seems to me to be fairly clear evidence, but of the *contemporary acquisition* of any new factor I see no satisfactory proof, though I admit there are rare examples which may be so interpreted. We are left with a picture of variation utterly different from that which we saw at first. Variation now stands out as a definite physiological event. We have done with the notion that Darwin came latterly to favor, that large differences can arise by accumulation of small differences. Such small differences are often mere ephemeral effects of conditions of life, and as such are not transmissible; but even small differences, when truly genetic, are factorial like the larger ones, and there is not the slightest reason for supposing that they are capable of summation. As to the origin or source of these positive separable factors, we are without any indication or surmise. By their effects we know them to be definite, as definite, say, as the organisms which produce diseases; but how they arise and how they come to take part in the composition of the living creature so that when present they are treated in cell-division as constituents of the germs, we cannot conjecture.

(*To be continued.*)

[3] The fact that in certain plants the male and female organs respectively carry distinct factors may be quoted as almost decisively negativing the suggestion that segregation is confined to the reduction division.

[4] I take the following from the Abstract of a recent Croonian Lecture "On the Origin of Mammals," delivered to the Royal Society: "In Upper Triassic times the larger Cynodonts preyed upon the large Anomodont, *Kannemeyeria*, and carried on their existence so long as these Anomodonts survived, but died out with them about the end of the Trias or in Rhætic times. The small Cynodonts, having neither small Anomodonts nor small Cotylosaurs to feed on, were forced to hunt the very active long-limbed Thecodonts. The greatly increased activity brought about that series of changes which formed the mammals—the flexible skin with hair, the four-chambered heart and warm blood, the loose jaw with teeth for mastication, an increased development of tactile sensation, and a great increase of cerebrum. Not improbably the attacks of the newly evolved Cynodont or mammalian type brought about a corresponding evolution in the Pseudosuchian Thecodonts which ultimately resulted in the formation of Dinosaurs and Birds." Broom, R., "Proc. Roy. Soc.," B., 87, p. 88.

Combined Effect of Electric and Magnetic Fields on Spectrum Lines

By J. Stark

The helium line λ4471.646 was found by Lohmann [Abstract No. 617 (1908)] to yield a normal Zeeman triplet in the transverse effect; but when subject to an electric field of from 20,000 to 30,000 volts/centimeters the line gives a quartet with two components oscillating parallel to the field and two perpendicular to it. Two cases of the transverse effect occur with superimposed electric and magnetic fields: (1) Electric and magnetic fields parallel to one another. The question then arises as to whether in this case the two electric components of the line oscillating perpendicular to the electric field are each separated into a doublet by the magnetic field, while the two components oscillating parallel to the electric field remain unaffected, or does another kind of electromagnetic separation take place. (2) Electric and magnetic fields perpendicular to one another. Do the two electric components oscillating parallel to the electric field each split up into a doublet under the action of the magnetic field, the two perpendicular components remaining unaffected, or does another type of separation occur here? Experiments are being undertaken with a view to elucidating these problems. It was found that by the admission of a certain amount of hydrogen to the helium in the discharge tube the light emission of the canal rays in the mixture is more intense than in pure He. A description is given, with diagrams, of the apparatus to be used for investigating the combined effect of the electric and magnetic fields. The results of the experiments will be published later.—*Deutsches Phys. Gesellschaft.*

Influence of Occluded Gases of the Selective Photoelectric Effect

By R. Pohl and P. Pringsheim

Potassium which had been boiled continuously for in one case 180 hours and in another 430 hours in an extremely good vacuum, whereby its yield of occluded hydrogen changed from 2 cubic centimeters to 4×10^{-4} cubic mentimeters per hour per cubic centimeter of potassium, was found to give the same selective photoelectric effect to within the limits of experimental error as potassium not so treated. The presence of hydrogen in the metal does not therefore appear to be of prime importance. This result is in direct opposition to that obtained by Wiedemann and Hallwachs [see Abstract No. 722 (1914)], the cause of which the authors are unable to explain. A general discussion on the causes of the emission of electrons by short electromagnetic waves, by chemical action, and by heat and the possibility of connecting them is included.—*Deutches Phys. Gesellschaft.*

Artificial Versus Natural Ice

Facts Showing that Wholesome Artificial Ice Can be Produced in Competition With the Natural Article

THAT artificial ice is not more generally produced, and used, is to be greatly regretted in view of the rapidly decreasing sources from which natural ice that is free from contamination can be obtained. Indeed, it would be difficult to find a stream or lake that is entirely free from suspicion.

From time immemorial it has been the custom of all people, both the savage and the supposedly civilized, to dispose of their refuse in the nearest stream or body of water on the principle "out of sight out of mind," and as this custom still prevails, with the rapidly increasing density of population, probably no body of water suitable for producing ice within a commercially practical distance of the regions where ice is required could be found that has not been subject to this primitive abuse of being converted into a sewer.

While natural ice, properly isolated, is entirely suitable for use in cold storage warehouses, and under similar conditions, there is no doubt but much that is now sold to the public is not fit for human consumption, and the time is not far off when official recognition of this fact will be made by the authorities charged with the supervision of pure foods.

A timely article on the production of artificial ice, and demonstrating that it can be produced and sold in competition with natural ice, by A. R. Smith of the engineering department of the General Electric Company, appears in the August issue of the *General Electric Review*, extracts from which are subjoined:

A luxury of to-day becomes a necessity of to-morrow, and conditions which we are content to endure at present are almost unbearable when one becomes accustomed to better conditions. These statements are pertinent to the users of natural ice. It is strange how critical is a community using artificial ice, but the fact is that artificial ice rejected by the customers in the South would be accepted as good quality ice by the patrons of the natural product. Now, why is it that there is so little competition between natural and artificial products in colder climates? Is it the general belief that artificial ice cannot be sold at the same price as natural ice; or, that there is no market for good ice at a slightly increased cost; or, that the initial investment for an ice plant is so great that capital cannot be readily obtained? The writer will attempt to dispel any such views by comparing the quality of ice and the cost of production.

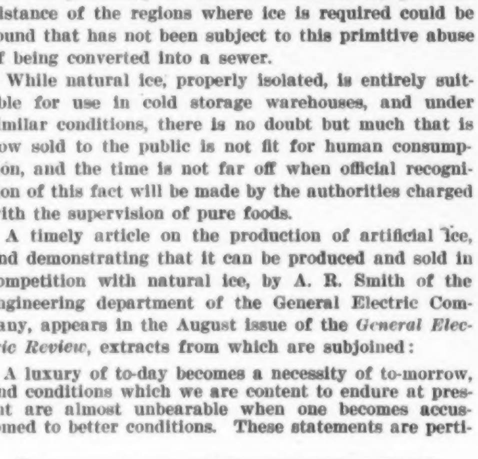


Fig. 1.—A representation of an average load curve for a 120-ton ice plant.

The fact that artificial ice is being marketed in the South at the same price and in some cases cheaper than natural ice is sold in the North, is very good evidence that competition is feasible in colder climates. As an example, an ice plant manufacturing ice at the rate of 20,000 tons per year and distributing to a trade within a radius of five miles, retails the ice at $8 per ton; whereas, in a Northern city of 100,000 inhabitants, a company harvesting approximately 30,000 tons per year and distributing within a radius of two miles, retails it at $12 per ton.

It is true that the ice season extends over a longer period in the South, but there is not so great a difference as one might imagine. It is also true that in the South the coal and ice business is frequently combined, and the same help and teams are used all the year round, which condition is not so applicable to Northern cities, where the majority of people purchase their winter coal supply in the summer. But the superiority of artificial ice should result in a market the entire year when sold in conjunction with natural ice. And, because of the reduced cost of manufacturing ice under high load factor conditions, it should be possible to make a better price to those who purchase ice at all seasons of the year.

Estimates are given in the *Review* which show that a plant of 120 tons daily capacity, or 23,340 tons a year, would cost approximately $92,000, on which the fixed charges would be 45½ cents per ton, while the cost of production would be 93⅓ cents, making a total of $1.89 per ton as against 29.8 cents for natural ice. These figures, however, do not cover the cost of distribution.

From the above it will be noted that if artificial ice is sold at $9 per ton and natural ice at $8 per ton, the excess cost of the former would be compensated for.

Fig. 3.—Illustration of a cake of artificial ice manufactured from distilled water.

Or, if both are sold at $8 per ton, the percentage of the selling price remaining to cover the cost of distribution and profits would be 82¾ per cent, 84½ per cent, and 96 per cent, respectively. However, the cost of distributing artificial ice should be less than natural ice because the delivery men are not required to cleanse each cake.

Ice is frequently cut from lakes, ponds, and streams, the water of which would not be considered suitable for drinking purposes, filtered or unfiltered. This ice may be used in drinking water on the claim that the process of freezing purifies it. Acknowledging that this purification is true under certain conditions, because any visible impurities in artificial ice usually find their way to the core, the last part frozen, there are other considerations which would indicate that impurities can be entrapped. Ice is frequently permeated with particles of coke expelled from passing locomotives; impurities from the air are deposited on top of the ice by falling snow or rain and frozen fast to it; a fracture in the ice often causes the surface to be flooded, carrying with it stream sewage and other impurities, all of which may be entrapped by freezing.

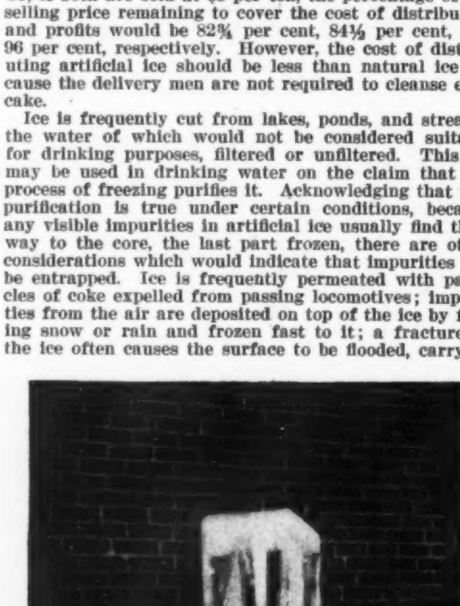


Fig. 4.—Another illustration of the cake of ice shown in Fig. 3. The central core which here appears to have considerable width would be only of line width in an edge-on view.

If it is conceded that natural ice should not be used as a direct cooling agent for drinks and edibles, then it loses one of its very important functions. However, it would be quite impractical to legislate against such use, and even difficult to evade the use of it personally when eating or drinking in public places.

Complaints on artificial ice are not unheard of, and they may be as follows: Salty ice, taste of ammonia, odor in core, presence of oil, presence of iron oxide.

In the can system, the cans are set in a brine, consisting usually of common salt water, but sometimes of a solution of calcium chloride. Should a leak develop and the water become salty, it will be detected by its flaky appearance immediately upon the removal of the cake from the can.

Ammonia contamination may occur in the double pipe pre-coolers, or the storage tank. But the former can be entirely dispensed with, with little effect on the cost, and the latter can be absolutely safeguarded by using continuous or welded expansion coils.

The odor in the core which may arise from the presence of oil is entirely eliminated when the water for making ice is obtained from the turbine condensers, as the steam never comes in contact with any lubricating oils. Odor arising from foul boilers is inexcusable if the boilers are properly cleaned and excessive use of boiler compounds avoided.

The presence of rust in the ice can be avoided by using galvanized or tinned piping and utensils for the distilled water, and exercising proper care to prevent oxidation when plant is not in operation, or by using brass piping.

Starting with the city drinking water or pure well water, it is first evaporated in the boilers, and then, after passing through the turbine, is condensed in a surface condenser. From the condenser it is pumped by means of a centrifugal pump to the reboilers, where it is thoroughly boiled to drive off the air and automatically skimmed of any floating material. Thence it passes through pipe coolers, where contamination from the cooling water can successfully be prevented, to charcoal filters and to the storage tank for filling the cans. In some cases it is again filtered through cheese cloth before entering the cans, but this operation should be unnecessary. The distilling process above mentioned destroys all bacterial life.

A quarter to one third of the natural product is what might be termed "snow ice." This contains usually most of the impurities and melts rapidly because of its spongy nature and consequently more surface exposed to the air. There is no difference in the lasting qualities of the crystal or clear ice, whether produced artificially or by nature.

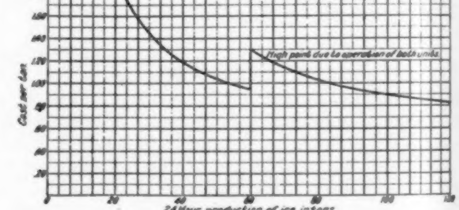


Fig. 2.—Curve showing the cost per ton of ice at different rates of production in a 120-ton plant.

A good quality of artificial ice contains no air except a slight trace forming the core, thus practically the entire weight represents crystal ice. In fact, cloudy artificial ice which may contain only a thin film of air lines just inside the surface and representing a much better grade than the natural product, would be rejected by the trade.

The actual weight of a cake of natural ice is a very uncertain quantity because of the irregular sizes and the loss due to melting in storage and during transportation. A 300-pound cake of artificial ice ought to weigh from 315 to 320 pounds to provide for shrinkage during delivery; and the weight is determined by setting of the automatic filler. The ice enters the handling room or storage room at approximately the freezing temperature, which should be about 14 deg. Fahr. Both these rooms are refrigerated to a temperature below 32 deg. Fahr. and there is no melting loss or necessity for packing with straw, sawdust, or the like. Really, the major portion of the ice is delivered to the wagons at a temperature somewhere between 14 and 30 deg. Fahr., depending on how long it stood in the handling room and how much heat was added to loosen it from the can. Therefore, a certain quantity of heat has to be absorbed by the ice before it reaches melting temperature, a distinct advantage over the natural ice which leaves the storage at just 32 deg. Fahr.

The reader should understand that there are many different and distinct systems of manufacturing ice from raw and distilled water and with and without compressors, and that the foregoing description applies to a comparatively commonplace can system.

New Divisions of the Inch

CERTAIN multiples or aliquot parts of an inch have been officially approved and verified by the Board of Trade, and will be recognized in England after November 1st. According to the schedule of the new denominations, the descriptive number of the equivalent of an inch is 15/0 B.G. (Birmingham gage). The new numbers proceed by units down to 1/0 B.G. (0.3964 inch), and then from 1 B.G. (0.3532 inch) to 52 B.G. (0.00095 inch).

Prof. William Bateson

President of British Association for the Advancement of Science.

Prof. William Bateson, F.R.S., the President-elect of the British Association, was born at Whitby, on August 8th, 1861, the son of the late Rev. W. H. Bateson, D.D., sometime Master of St. John's College, Cambridge. Educated in the first instance at Temple Grove School, he obtained a foundation scholarship at Rugby, afterward graduating at St. John's College, Cambridge. In 1885, Bateson was elected to a Fellowship of his College, and in 1887 became Balfour Student. The Royal Society conferred its Fellowship in 1894, and in 1904 he received the Darwin medal of that body for his researches on heredity and variation. Cambridge University elected him Professor of Biology in 1908, a post he held for a year, becoming then Director of the newly-founded John Innes Horticultural Institution at Merton Park, Surrey. In 1912, he was made Fullerian Professor of Physiology at the Royal Institution, a triennial appointment, shortly to be vacated.

Investigations in various departments of Zoology occupied the early part of Prof. Bateson's career, in particular, a research on the structure and development of Balanoglossus (the general name, it should be said, given to certain peculiar opaque worm-like animals which live an obscure life under stones, and burrow in sand, from between tide-marks down to the abyssal regions of the sea). The material was collected in America during visits to the Marine Laboratory of the Johns Hopkins University, Baltimore, and subsequently a series of papers on the research appeared in the *Quarterly Journal of Microscopical Science*. In 1886–87, he visited the Aral Sea, and the other salt, alkaline and bitter lakes in Western Central Asia, in order to study the fauna and any structural variations correlated with the existing life conditions.

Recognizing that variation was the bedrock upon which the theory of evolution rested, Prof. Bateson devoted himself to its study, and in 1894 published his "Materials for the Study of Variation." When, in 1900, biologists came to appreciate the researches of Gregor Johann Mendel, of Brünn (published as far back as 1865, but long overlooked) on the workings of heredity, as exemplified by experiments on the sowings of varieties of edible peas, Prof. Bateson took up the subject with enthusiasm, and soon announced that "with the re-discovery and confirmation of the principle which will henceforth be known as 'Mendel's Law,' the study of heredity and the cognate problems of evolution must enter on a new phase." In 1902 there appeared his "Mendel's Principles of Heredity."

Prof. William Bateson

The conclusions of Mendel's experiments have been admirably summarized by the Rev. W. Wilks, the distinguished horticulturist, he who gave us the famous Shirley poppy. If you cross pure yellow and pure green peas either way—it matters not which is seed-bearer and which pollen-bearer—you will get all yellow seeds. If you sow these hybrid seeds, each will, if it germinates, produce a plant which will bear, say, forty seeds, thirty of which will on the average be yellow, and ten green. The green, if sown and sown and sown for countless generations, will always bear green seeds, true to the original green parents (barring the always possible intervention of insects). Not so the thirty yellow. These when sown will on the average produce ten plants bearing all pure yellow seeds, which will be constant and true to the original yellow parent for countless generations. The remaining twenty plants will be impure yellows, each plant producing on the average one quarter of their seeds pure yellow, one quarter pure green, and one half impure yellow, which last will repeat the process and proportion practically for ever.

This law of inheritance, or ratio of results, forms the basis of that extension and application to general problems of heredity and variation, now so actively pursued by Prof. Bateson and his co-workers, among whom may be mentioned, Miss E. R. Saunders, Mr. R. C. Punnett, Miss Durham, Mr. L. Doncaster, and Mr. R. H. Biffen.

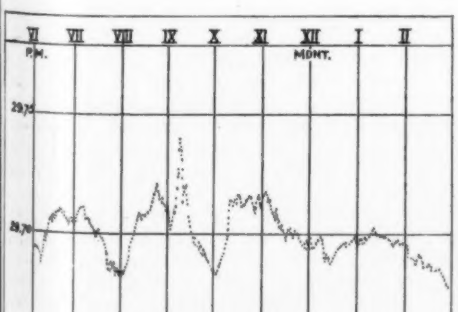
Prof. Bateson was Silliman Lecturer, Yale University, in 1907, when he discoursed on the bearing of Mendelian methods of analysis upon some of the wider problems of biology. These lectures were recently published in book form under the title, "Problems of Genetics."

Thread-Recording Micro-Barometer

The instrument from which the tracings here reproduced were obtained is a comparatively new type of recording apparatus in which friction is almost completely eliminated. The recording arm, or boom, of the aneroid is left free and unloaded by a pen; this means that the instrument can be made very sensitive, and is able to respond to the most minute variations of atmospheric pressure.

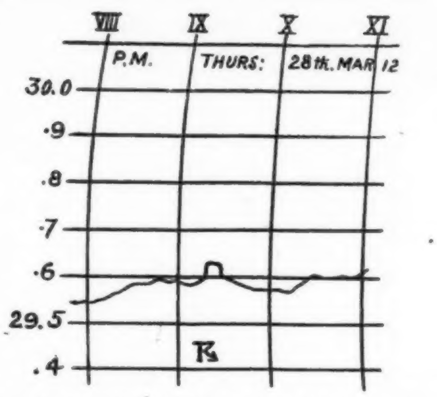
The principle made use of is that known as that of the "thread recorder"—a method of obtaining records from any delicate indicator—and originally applied to a ship's course recorder, or recording compass, by the inventor in 1902-1903. It consists essentially of an endless thread stretched on pulleys across and above the surface of the diagram, and kept continuously reinked in its passage over an inking roller. A slow motion is given to this thread by the driving clock. The end of the indicating arm is flattened so as to present its edge to the thread above which it swings. At intervals of one minute, or more frequently if required, this arm is pressed by a lever bar against the thread, forcing it down on the diagram, and thus making a dot. The individual minute dots can be seen in places where the increase or decrease of pressure has been rapid.

The photo reproduced herewith shows an instrument of this kind with paper 15 inches wide, and sufficient on one roll to last six months at the normal speed of one inch per hour. The record is automatically rewound on a second spool, from which it can be removed at any time.



Tracing from record given by a new form of micro-barometer during the passage of the thunderstorm and electrical disturbance of March 28th, 1912.

Showing the rapid fluctuations in atmospheric pressure usually associated with the presence of such disturbances. Magnification, 25 times; 2½ inches on diagram equals one tenth of an inch of mercury barometer.

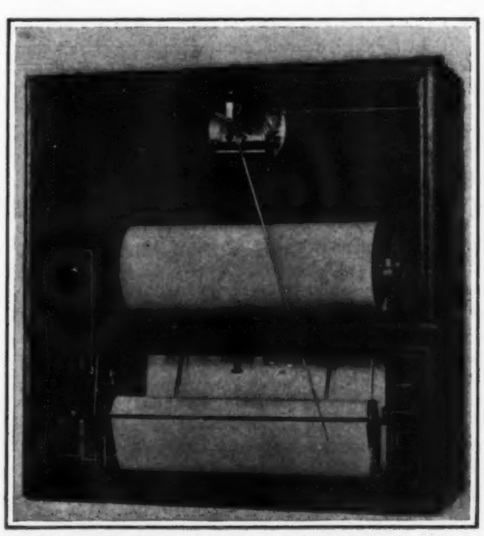


Reproduction of a tracing (actual size) from one of the barographs of the Weather Bureau, Sydney Observatory, about three quarters of a mile distant from where the micro-barograph was situated.

The line drawing shows another design in which the record is visible for twenty-four hours after marking, and is rewound on a large diameter drum fixed outside the case for easier access.

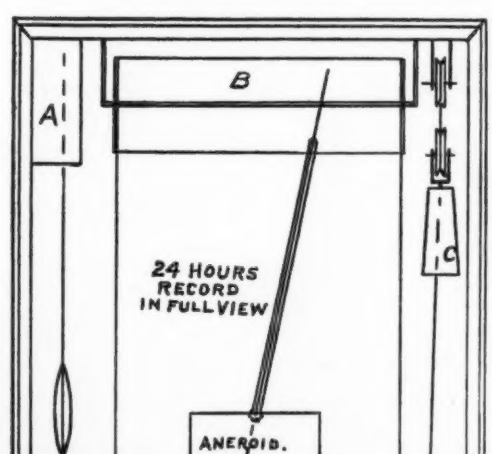
Unlike other micro-barographs which act on the "leaking off" principle, the diagrams of this instrument show the variations of atmospheric pressure in their relatively true value and correct sequence; while the time divisions are represented by straight lines.

In the latest design the driving clock is electric; the instrument is thus perfectly automatic, and may be left unattended for months at a time. The thread does not require attention more than two or three times a year.



Thread-recording micro-barometer supplied to the Weather Bureau, Melbourne.

Safety During Thunder Storms.—It would seem that the popular theory that a motorcar is one of the safest places during a severe thunder storm is also a popular fallacy. The idea that the rubber tires will act as an effectual bar to the passage of the electrical discharge may be exploded by anyone with the intrepidity to stand beside a car and place one finger upon the top of a spark plug with the motor running. The high tension current readily finds a path to the ground regardless of the tires. Why should not a bolt of lightning find a similar path?



Improved form of "thread-recording" micro-barometer.

A, Electric clock and pendulum; *B*, roll of paper 15 inches wide, six months' supply at 1 inch per hour; *C*, weight actuating rewinding drum, giving uniform pull on paper—one wind per month; *D*, rewinding drum, 8 inches diameter, fixed outside case; *E*, case, 2 feet 2 inches square, by 8 inches deep.

Liquid Crystals and Biology*

Discovery of New Properties of Matter Assist the Study of the Secret of Life

By Prof. O. Lehmann

THE matter forming the physical basis of living organisms is usually regarded as a colloid substance, a mixture of extremely finely divided solid matter with a liquid of jelly-like consistency, or an emulsion of two liquids. Since such a mixture has no orderly structure, it is difficult to comprehend how the manifold, often very regular forms shown by organisms have come into existence and restore themselves after injury. Likewise the dynamic effects shown by organisms, as for instance the movement of an amœba in a definite direction, are not easily reconciled with the colloid nature of living matter. If, say, as a result of stimulation, the mass were to possess anisotropic structure, if only locally and temporarily, then the streaming of protoplasm would be far more comprehensible from a physical standpoint.

The chief objection to such an assumption is the presupposition that anisotropic structure can belong only to brittle solid bodies—the crystals, and that plastic and fluid crystals are an impossibility. Of course this follows from the old, almost axiomatic "theory of identity," according to which for example, ice water and steam have identical molecules, these molecules being arranged in different aggregates, as is supposed to be the case with the polymorphous modifications of sulphur. According to this old form of presenting the case the molecules of a molten mass are freely movable among themselves since cohesion and molecular directive force are supposed to be entirely overcome by the violent thermic motion of the molten state. At the instant of solidification all this is reversed and the molecules are supposed to "snap," as it were, into orderly arrangement, into so fixed a relationship that the thermic motion is entirely overcome, and all plasticity lost.

Since certain crystalline substances, especially metals, appear to be plastic as well as amorphous, the physicist labored under the necessity of explaining this phenomenon by assuming a shattering and then a re-welding of the fragments, the latter taking place by parallel shifting (translation).

Fluidity of a crystal, due to disturbance of its molecular arrangement, seemed inconceivable, since only two stable molecular arrangements were held to be possible, the absolute irregularity of the molten state and the perfectly regular disposition of the molecules in crystals.

Now, according to my results, between these two extremes of perfectly regular and entirely irregular molecular arrangement, a great number of intermediate forms are possible, the equilibrium between molecular forces and thermic motion is a stable equilibrium, changing with the temperature, and the apparent "snapping of the molecules" into order is merely an erroneous supposition, since in reality it is a sudden alteration in the molecules themselves which occurs, and which naturally occasions sharp transformations in the molecular forces. Furthermore, I found that through such molecular changes through the action of molecular directive force, mechanical work may be obtained, and that, too, directly from chemical energy, as in the case of work done by organisms.

My work began with the study of ammonium nitrate, and my object was, from the start, the observation of the life processes in organisms, the reasons for the forms they assume, and their power to do work, and comparison of these phenomena with those seen in non-living matter.

I found that the modification which appears with solidification of the molten mass at 161 degrees consists of very soft regular crystals, which again on cooling to 125.6 degrees first really crystallize in a tetragonal modification exactly as if they were liquid crystals. This again solidifies to a still stiffer monoclinic form at 82.8 degrees, which in turn at 32.4 degrees assumes a rhombic form, while at —16 degrees a tetragonal modification appears. On reheating, the substance "melts" into the ever softer modifications at the same temperatures. Here again the transformation cannot consist in the accepted "snapping" of the unchanged molecules into new arrangements, since in that case the observed identity of temperatures for the backward and forward change would be an impossibility, but the limiting temperatures to which the mass could be cooled or heated without snapping from one molecular arrangement into another would vary the more the greater the degree of firmness of the transformation.

The identity of the ordinary points of melting and solidification had already been seen to contradict the "snap-theory" as does still more the existence of these transformation temperatures.

Moreover the significant alteration in characteristics, coincident with polymorphous transformations cannot be explained by this theory. I found that the long needles of the monoclinic form of ammonium nitrate could be bent into rings without injury to their transparency, and that they showed not the least variation in solubility at different points, although their molecular arrangement must have suffered much more static change than in any "shattering" process, of which there was not a trace. Also in polymorphous modifications no change in solubility could occur without a change in the molecules themselves as well as in their arrangement.

I was able to establish the possibility of disturbing the molecular arrangement by the admixture of foreign substances; naturally this had been excluded from the realm of possibility, the coloring of minerals and the artificial coloring of salts (Senâmont) being regarded as a locking up of particles of coloring matter in so far as their molecules could not be considered so far similar physically and chemically (isomorphic) that they could replace those of the substance colored without destruction of the molecular arrangement.

Now isomorphic enmeshment (investiture) occasioned, according to my results, twisting and warping, which produced spherical crystals with a whole series of transitional forms between these and the normal crystals. These spherical forms are definitely recognizable as crystals, although the molecular order has been disturbed in the highest degree.

Of course, according to the old theory of crystallization, the formation of a liquid crystal is impossible, a crystal constantly altering and restoring its molecular order. The snapping into being is thought of as an irreversible process, which assumes the presence of a "limit of elasticity" (the internal friction of rest). Fluids are by definition bodies without a limit of elasticity, hence the absurdity of the whole idea. After I had recognized the accepted theory as false, it then became possible for me to entertain the idea of liquid crystals. The study of silver nitrate gave me the direct inspiration. At first I thought the modification appearing above 146 degrees amorphous and viscous, finding later that it was made up of regular crystals. Were these crystals then viscous? The decision could rest only on a determination of the limit of elasticity, which is the characteristic of the solid state, and for practical reasons this determination could not be carried out.

While I was considering these questions, F. Reinitzer sent me for examination a preparation of cholesteryl-benzoate, of which he wished to determine the molecular weight, which, however, when molten, was an opaque mass, the nature of which he could not clearly make out. He thought the opacity, which occurred on cooling, was due to the separation of solid crystals out of an isotropic molten mass, and that on raising the temperature oily streaks should appear in the molten mass of a modification more easily melted. Since for me the characteristic of a crystal was its ability to grow in polyhedric form, and since I could not find these shapes, I was at first at a loss; only after tedious study did I discover that the (apparently, not really) isotropic fluid containing the oily streaks is different from the isotropic molten mass, and has the same solubility as the oily streaks and crystals; also that it arises from these without change of temperature; therefore, I conjectured that we might here be dealing with liquid crystals, more fluid than those of silver iodide. Phenomena which I observed in a preparation sent me by L. Gattermann, also turbid when molten, strengthened my supposition of the existence of liquid crystals, but proof was lacking since I could not find the polyhedric form, the characteristic of crystals.

Real proof I obtained first with the hydrate of ammonium oleate, the myelin forms of which had already aroused my interest. Although these are typical liquid crystals, I did not immediately recognize them as such; first, because I did not find the distinguishing mark of polyhedric form, and second because they were regarded as tubular sacks of precipitation membrane (G. Quincke and others). So matters stood when the turbid iridescent molten cholesteryl-benzoate came up for study. Reinitzer's assumption that it was a jelly or an emulsion seemed probable, and there was nothing to be seen of fluid crystals, so naturally my conjecture aroused strong opposition, especially since the appearances were identical with those of the jelly-like myelin forms of ammonium oleate. I took up again the study of ammonium oleate, and with this obtained the irrefutable proof of the existence of liquid crystals. I saw crystals which have the peculiarity when agitated of flowing together like two drops of liquid, and in such a way that the normal order of equilibrium of the molecules and the normal form are again restored, as shown by optical and mechanical relations. This phenomenon I called "spontaneous homoötropy." It was something entirely new.

In the case of these crystals there can have been no "sapping" into fixed molecular order, and there can be no state of stress as when elastic or plastic solid crystals are bent. Their molecules behave rather like free-moving astatic magnetic systems in constant motion, yet in stable equilibrium in their orientation. Every twist out of the natural position of equilibrium vanishes instantly as a result of molecular directive energy, since continuous elastic tension cannot exist. The limit of elasticity must then be zero. The crystals not only can but must be described as liquid. Lecithin has been found to occur in liquid crystalline form, and we may find the same true of cholinoleate and protagon.

Protagon, lecithin, cholesterin-ester, and oleate are found in brain, nerves, etc., and are extremely important to all vital processes.

Probably these are not the only liquid crystalline substances contained in living matter, since their recognition as such came about through their double refraction, which may be so slight, in case it exists at all, as to be entirely unobservable in microscopic layers. Hence it cannot be decided microscopically whether a liquid seen only in layers of microscopic thickness is amorphous or crystalline. Even in case of the above-named substances this occasionally proves true in so far as their double refraction can be altered by a loose combination with other matter (especially water) as is true of solid crystals. For example, if water is gradually added to a solution of ammonium oleate hydrate then instead of the small slender pointed crystals, more and more rounded ones appear; plainly there is formed a combination richer in water, which enmeshes itself regularly oriented in the liquid crystals of the form poorer in water.

If normal liquid crystals of ammonium oleate hydrate are brought into contact with water (better spirits of ammonia) myelin forms appear, which are nothing less than mixed crystals of this sort, especially rich in water, and in which the optical axis stands everywhere radial to the cylindrical axis. The double refraction diminishes as the amount of contained water increases. Phrenosin or protagon swell like starch grains when warmed in water, giving rise to myelin forms in which double refraction disappears entirely, although the mechanical properties which distinguish them from amorphous or colloid matter remain unchanged, i. e., the ability to form themselves (and that without growing, like solid crystals) merely through the establishment of their internal molecular equilibrium, while maintaining their normal structure or producing mechanical work.

In all these points there are striking analogies between the behavior of these liquid crystals and the characteristics of living matter, so that the designation, "apparently living crystals" might in many cases be entirely justifiable. Among colloid substances no such analogies exist.

I cannot go into details here, but must emphasize the fact that the formation of tubular and cell-like hollow myelin forms is an entirely different matter from the formation of "artificial cells" out of colloid matter. The latter grow as a result of osmotic pressure and are closed precipitation membranes. If they are opened at any point, then of course the higher pressure within vanishes, and growth is no longer possible.

In myelin forms, on the contrary, growth is not disturbed in this way; here the pressure is less within and the low pressure enables them to suck in foreign substances like a cupping glass. This is the direct cause of their growth and peculiar structure, which exactly corresponds with the structure taken on by a liquid crystalline mass when sucked up into a very fine capillary tube. If an isotropic substance is also drawn up then this forms a long cylindrical bubble in the axis of the tube exactly as in the case of hollow myelin forms.

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the *Biochemische Zeitschrift*, Band 63, Heft 1.

The low pressure within is the result of the stretching of the outer layers due to swelling. The work thus produced corresponds to the energy lost in the swelling, the chemical energy. With absorption of water, swelling occurs also on the inner surface, so that such open hollow myelin forms occasionally do not remain cylindrical, but may become bell-shaped.

The swelling is not to be confused with diffusion. The liquid crystal is no porous mass into whose pores any liquid whatever may be absorbed; but the foreign material first forms a loose chemical combination with the outermost layer, at the boundary between this and the next layer dissociation occurs, and a part combines with the subjacent layer, and so on, penetration taking place not simply by diffusion, but by a chemical process; the source of energy is then largely chemical energy.

Not alone through swelling can manifestations of energy occur, but also through transformations, that is, alterations in the molecules, where, since the transformation is a chemical process, the source of the power to do work is again chemical. Such dynamic effects are very striking in the myelin forms of protagon, which on solidification suddenly shorten themselves by half without alteration of their optical orientation, and on being warmed, as suddenly reassume their former mass. Even more interesting is the phenomenon seen in the myelin forms of ammonium oleate, which, on being cooled below —4 degrees suddenly tries to expand, being transformed into a mass of cylindrical rods of identical optical orientation and striking against one another at all angles; and which on being warmed above —4 degrees as suddenly reassume the usual curved forms. Here we have to do not with real solidification, but with a transformation into a viscous liquid crystalline modification.

At bottom all these dynamic effects are expressions of molecular directive energy, the effects of revolving electrons.

Attention has been called to the fact that in liquid crystals piezo-electrical phenomena might appear, which might possibly be related to the electric currents set up in connection with muscle contractions and with the transmission of stimuli in nerves.

Nothing definite has yet been done in this field; the study of myelin forms being still in its infancy.

Protection Against Fire on Board Ship

It is a remarkable fact that, notwithstanding the great developments that have taken place in every detail in the design of merchant steamships, little or no progress has been made toward the effectual protection of the vessel against fire excepting, perhaps, in the direction of improvements in the pumps and in the distribution of pressure water from them. In the case of warships it has for some years been realized that one of the dangers to be met in naval engagements is fire, due to the action of the explosive contents of the shells which may penetrate into the interior of the ship; and progress has been made in the direction of insuring that the whole of the interior fittings shall be of a non-combustible material. It cannot be said that there has been great loss in decorative effect, although in this matter the warship is in an entirely different position from the modern liner. No attempt has been made, even in warships, to introduce furniture made of metal which will resist fire, the theory being that, before an engagement is entered upon, all wooden furniture, as well as all portable combustible material, etc., will be jettisoned.

In the merchant service there is not the same risk of fire as with warships in action, but statistics show that during the past eight or ten years there have been annual averages of over 300 outbreaks of fire on board ship, either in port or at sea, while the number of ships completely destroyed by fire averages over twenty per annum. This may not seem a large figure when one remembers that on the register of the United Kingdom alone there are nearly 21,000 ships, and that probably throughout the world there are 50,000 ships continuously in service. At the same time the possible loss of life, and the probable destruction of property consequent on fire, should encourage careful consideration of all possible methods, not only of preventing an outbreak, but of quickly and effectually arresting it in the initial stages. Undoubtedly in the case of passenger ships the publication of the fact that something had been done toward this end would have an effect on the bookings corresponding to that resulting from the evidence given of the possession of life-boats for all. In the new Hamburg-American liners "Imperator" and "Vaterland," Grinnell sprinklers have been introduced, and this fact alone justifies a consideration of the effectiveness of this method of combating fire on board a ship.

The extent to which such automatic sprinklers are used in mills, factories, warehouses, stores, halls, theaters, etc., and the disposition of fire insurance companies to grant rebate on the premiums of fire insurance policies when sprinklers are fitted, is evidence in favor of the efficacy of the same system on board ship. The conditions, particularly in the passenger quarters, are most favorable, because here the space is so minutely divided up by iron decks, transverse bulkheads, and even by cabin and alleyway walls, that the initial outbreak of a fire is confined within a limited area, and were automatic sprinklers immediately brought into action, the fire would the more likely be quenched. As to the freezing of the water in the pipes—an argument sometimes used against the system—the dry-pipe system has proved an effective preventive. In this system, so-called pressure tanks are provided, containing sufficient water for a primary supply, and this water is held in check by a specially designed differential valve, having water pressure on one side and air pressure on the other. When the rise in temperature, due to the starting of a fire, melts the solder of the sprinkler, the opening of the head liberates the air, reducing the pressure, and the valve is opened by the water-pressure above it exceeding the air-pressure under it. Thus the water flows freely through the pipes and out of the open heads. The inspection department of the Associated Factory Mutual Fire Insurance Companies of America, which has been responsible for the fitting of sprinklers to quite a number of American ships, including coasting, river and lake passenger-steamers, estimates that with any sprinkler system on board ship the heads would be spaced about 10 feet apart, each protecting 100 square feet, and that the cost of such an installation would average about 16 shillings per head, excluding the cost of the pumps. In land practice the cost is only about 12 shillings per head, but the ship installation would probably cost more.

The treatment of holds where cargo is carried involves a special application, particularly where the cargo is of a material with a tendency to spontaneous combustion. It would be difficult for sprinklers, and even for a hose, to subdue a fire of this nature, although it might postpone serious consequences sufficiently long to enable the ship to reach port. The authority already quoted has adopted a system of introducing carbon dioxide into warehouse compartments, which are analogous to ships' holds. The carbon dioxide is purchasable in a form liquefied under pressure and contained in drums. The liquid gas is passed through pipes and exudes through openings at the top of the warehouse or hold, its specific gravity causing it to sink, and thus to penetrate the interstices of the cargo during its descent; the result is that combustion is rendered impossible, and the fire is either held in check or completely extinguished, the gas ultimately being driven out or sucked out by fans. The difficulty is that the carbon dioxide, though not explosive or directly dangerous to life, tends toward asphyxiation. But a man can live for a limited time in an atmosphere containing 10 to 15 per cent of it, and it is computed that from 30 to 40 per cent is sufficient to extinguish a fire. It is not dangerous to merchandise, and the quantity required is about a 50 pound cylinder per 1,000 cubic feet of air. Sulphur dioxide has been used, but the authority quoted found it objectionable, as men could not live in an atmosphere containing any appreciable amount of the gas; moreover, it is injurious to certain kinds of merchandise.

In addition to this means of extinguishing an outbreak, consideration should be had, in merchant-ship practice, to the adoption to a larger extent of metal in preference to wood. It is true that so-called fire-resisting paints are largely used, but there is doubt of the efficacy of the great majority of such paints. In preference to wood a light steel might be used, especially if lined with non-combustible insulating material in order to secure a more equable temperature within the cabins in climates where extreme weather conditions prevail. In recent years there has been considerable development in the simulation of wood-carving and decorative effect generally in the production of metal furniture; but, even so, we are a long way from achieving the artistic effects which can be got from wood. In the modern liner, however, plaster-of-paris, and other such materials are being more and more relied upon for decorative purposes. Indeed, in some of the newer ships it is difficult to grasp the fact that one is not in a room on shore, because of the treatment of the ceiling and walls. If this plaster-of-paris work proves to be lasting, a way is opened up for the use of light-steel partition walls with insulating materials in preference, or in addition, to the plaster-of-paris.

The question is largely one of expense. The substitution of steel and plaster for wooden decks, cabins, etc., in medium and large passenger vessels would involve an increase in expenditure up to 10 per cent of the cost of the entire ship, excluding even the extra cost of steel furniture, if such were used. This is a serious addition to the price of a ship, and when to it there has to be added the cost of automatic sprinklers, it will be obvious that the shipowner will have to consider whether the advantage accruing from increase in favor with the public, and consequently more consistently full passenger lists, with the addition of a reduction of insurance rates, can compensate him for the expenditure. There can be no question that a ship so treated would be more immune from the risks of fire than an ordinary vessel depending only upon the fire-pumps; but the final answer is, we fear, one concerned with the relation of safety, and its influence on earning power, to the cost involved. The matter is one that will be decided finally by the public. If they make it clear that they are ready to pay for increased security, then it is certain to be attained, for manufacturers will vie with one another in discovering new materials, and in devising novel methods of treating old ones to render them durable and artistic. Shipowners have shown such readiness to add to the comfort and speed of their vessels that there is no doubt they will meet all demands that are commercially practicable.

* Reproduced from *Engineering*.

Theory of Compressible Atoms*

By Theodore W. Richards

Speculation concerning the ultimate nature of matter goes far back into the early history of mankind. As soon as several of the ancient Greek philosophers perceived that some kind of atomic hypothesis was the simplest method of accounting for things, they attempted to imagine the nature of the ultimate particles. The apparent permanence of the Universe suggested that these particles could never become worn out, and hence the ancients naively conceived of them as being indefinitely hard. Newton inherited this idea, and spoke more than once of "hard massy particles." Not much over a hundred years ago Dalton brought forward convincing quantitative evidence in favor of the atomic theory, putting it thus upon a firm basis; and the theory was later adopted by physicists to explain the pressure of gases. Throughout these considerations the ancient notion of hard, incompressible, but perfectly resilient, atoms persisted—partly because this assumption served as a convenient basis for mathematical analysis.

According to the tenets generally held during the last fifty years, solids and liquids, as well as gases, are supposed to be constituted of small hard atoms (or complexes of hard atoms called molecules) with wide empty spaces between them—these atoms being supposed to be each for itself in violent irregular motion to and fro, due to heat. There is, however, nothing in this philosophy to distinguish solids and liquids from gases, although in reality they are very different indeed. Such a conception gives a very reasonable picture of the state of a gas, but does not explain the fixed bulk of liquids nor the rigidity and impermeability of solids. To overcome these difficulties it was necessary in discussing solids and liquids to add to the hard imaginary incompressible particle a magic "sphere of influence" surrounding it, which would prevent its touching other atoms; but how this "sphere of influence" was constituted no one was quite prepared to say.

About fourteen years ago in studying the behavior of gases, I came to the conclusion that even with this dilute form of matter, the imaginary particles (although here widely separated) were still surrounded by "spheres of influence," somewhat but not very much larger than those imagined to exist in liquids; and it seemed that since a "sphere of influence" appears always to accompany the atom, the little hard particle in the middle might have no real physical significance; this imaginary hard particle appeared to be a purely arbitrary assumption. The so-called "sphere of influence" in all its relations acts as if it were really the important thing to be considered. Hence the question was proposed: Why should we not call this sphere of influence the atom itself, since it always accompanies the atom, and why should we pretend to know anything about how the material is distributed within its limits? The gain in this point of view is twofold. In the first place it concentrates the interest and attention upon the entity which actually comes into consideration; on the other hand, it abolishes an arbitrary hypothesis.

If we consider the "sphere of influence" as being the practical boundary of the atom, we must call the atom compressible, for the "sphere of influence" is compressible; in other words, liquids and solids are actually compressed when pressure is applied to them. If the atom is compressible and elastic throughout its substance, we may imagine vibration within it; thus heat

* So many partial, or inaccurate, statements of Prof. Richards's revolutionizing theory have been printed of late, that the Editor of the *Graduates' Magazine* requested him to prepare the above article. Reproduced from the Harvard *Graduates' Magazine*.

may be explained even in closely packed atoms of this kind.

One can easily see that the new hypothesis is suggestive. If the atoms are compressible and are packed closely together in solids and liquids, may we not trace, through the alteration in bulk of substances during chemical change, the action of the chemical and cohesive affinities which hold the atoms together? May we not with the help of this study interpret anew the mysterious symmetry of crystals? May we not correlate numerous properties in relation to one another and by means of the fundamental conception show the mutual dependence of all the properties of matter?

Perhaps the best method of indicating how such an idea can be of service is to enumerate the investigations which this particular hypothesis has already called into being, and the results to which they have led.

In the first place the hypothesis stimulated the study of the densities of solids and liquids, and thus led to the securing of decidedly convincing evidence that chemical affinity really exerts pressure in its action. This conclusion is based on the fact that the action of powerful affinity was found to be coincident with increase in density, other things being equal. Intimations of this effect are to be found in a note of Humphry Davy's, and in some later writings; but nobody had before taken account of its relation to the compressibility of the substances concerned.

A similar relationship was shown to hold in lesser degree with regard to the cohesion which holds together molecules of the same kind. Hence it appeared that non-volatile substances (which are firmly held together by cohesion) would be expected, other things being equal, to have great density, and great surface tension. Moreover, such substances (because already much compressed by great cohesion) should possess only slight compressibility. These conclusions likewise were verified by the study of fact.

The theory, since it involved the study of compressibility, led to the devising of a new and convenient method for determining this somewhat elusive property. With the help of this method the compressibilities of thirty-five elements were determined in Boylston Hall—only one or two having been known before. It was found that in the case of the solid elements the compressibility shows periodic fluctuation as the atomic weight increases, and that in general, with elements as with compounds, the bulky volatile substances are the most easily compressible. This was new—neither the facts nor the explanation had been available before. The study of compressibility has since been taken up by Dr. Bridgman in the Jefferson Physical Laboratory, and he has made great progress in the study of the effect of high pressures.

Further, the theory suggested that if atoms are compressible, the uneven compression caused by differently applied chemical affinities might restrict the heat vibration supposed to exist within their elastic interiors. This restriction would lessen their heat-capacities (which are measured by the quantities of heat needed to cause a given change of temperature) and at the same time expel some heat vibration already present which could no longer be accommodated by the diminished heat capacity. Thus the theory predicted that when during a given reaction the heat capacities of the substances concerned were diminished one would expect also to find an output of heat during this reaction in excess of that corresponding to the chemical work. This common-sense explanation of the puzzle involved in the idea of "bound energy" immediately stimulated investigation of the changes of heat capacity of substances in relation to the corresponding changes in the heat evolved during chemical reaction, and also prompted the study of specific heats at very low temperatures. After the main relations had been qualitatively demonstrated at Harvard, the matter was taken up by Nernst in Berlin, and later by others; and the qualitative predictions of the theory have been abundantly verified, even if the mathematical addition of some more recent investigators have not always been as effective as might be wished. The amplified idea has been called the "Third Law of Thermodynamics," and although by no means thoroughly worked out, it gives promise of fundamental importance.

Another suggestive application of the theory concerns the idea of the "asymmetric" or unsymmetrical carbon atom proposed by van 't Hoff, which is the basis of so much of modern organic chemistry. The actually observed phenomena are exactly what one would expect if a compressible carbon atom were unequally compressed on four different sides by the four different affinities inherent in four other dissimilar atoms. This and other aspects of the theory were set forth in detail in the Faraday Lecture delivered in London two years ago.

The most recently published application of the hypothesis is its interpretation of crystal form. In a paper which has just appeared in the *Journal of the American Chemical Society*, various phenomena exhibited by crystals—such as their definite angles, the similarity of forms assumed by similar substances, and other details concerning their highly symmetrical shapes—are all accounted for according to the theory of compressible atoms in a fashion which seems (at least to the author) to be more satisfactory than any other thus far suggested.

Incidentally it may be noted that the theory is entirely consistent with the still more recent idea that the "atoms" themselves are composed of yet smaller corpuscles, although on the other hand I can see no reason why indivisible particles should not be compressible.

The applications of the theory to the interpretation of chemical phenomena and to the suggestion of new research are by no means exhausted. No significant objection to it has thus far been encountered; but even supposing that the idea should be supplanted in the future by something yet more satisfactory—and this is always a possibility in the progress of scientific thought—one would be inclined to say that the theory had already justified its existence. The saying of Scripture: "By their fruits ye shall know them," applies in full force to theories as well as to persons, and in the short span of its existence the theory has been fruitful. It has "acquired merit" in the only way open to any such hypothesis, namely, by stimulating new experimentation, and thus leading to the discovery of facts and laws previously unknown.

The Cinematograph in Research

In an extremely interesting lecture before the Fränkisch-Oberpfälzischer Section of the Verein deutscher Ingenieure (*Zeitschrift des Ver. deut. Ing.*, 1914, lviii, 268), Dr. Ing. Hanz Goetz outlined the part cinematography had played in scientific and technical research, and suggested some of the things that may be expected of it in the future. After an introduction giving statistics, describing apparatus, and outlining the history of the invention, the lecturer takes up the position of moving picture photography among the means of reproducing phenomena to the census. It differs from other means in that it correlates two of the basic quantities that physics deals with, time and extension in space.

The most obvious way in which the cinematograph may act as an aid to science is in recording rare phenomena, such as scenes in the life of seldom seen or difficultly accessible animals, unusual surgical operations, etc.—fields in which considerable success has been attained. Its usefulness only begins here, however. Just as the scale of objects may be varied when they are represented graphically, so the time scale of actions may be changed when they are represented by the cinematograph. By an increase in speed, Prof. Pfeffer of Leipzig has been able to reproduce in three minutes a 10-day period of growth of a horse-chestnut twig; pictures for this reproduction were taken at 5-minute intervals. A large field for the study of the growth of both plants and animals is thus opened up. Just as slow motions can be hastened so that it is possible to see the total effect in a truer perspective, so it is possible to retard and analyze quick movements, and the limits are only those of the speed with which the pictures can be taken. With the most refined mechanical devices it is not possible to take more than 250 pictures per second, but by illuminating the moving object with regularly succeeding electric sparks and photographing on a film moving continuously rather than intermittently, it was found possible to increase the number of exposures to 2,000 per second. Bull has studied the flight of insects in this manner.

From an engineering point of view the cinematograph has been most useful in studying projectiles and their effect on armor plate. Much higher frequencies had to be used than Bull obtained, and the apparatus employed differed from his in not using a mechanical interrupter; in series with the illuminating spark-gap was a large condenser, and in parallel with it a small one; the large condenser is charged by an induction machine, and when it is discharged the small condenser is alternately charged and discharged across the gap. The period of the alternations can be judged with fair accuracy by the tone. Since an explosion can take place in the five-thousandth part of a second, the speed of nine to fifty thousand exposures per second, obtained by this method, is sufficient to furnish interesting results. Since it is obviously impossible to have the camera near the object photographed, a special arrangement is used.

The cinematograph can also be used for making quantitative measurements of movements. The fall of a body has been studied by photographing on the same film the falling object and the hand of a chronograph, and in the same way the action of a steam hammer has been timed.

In these lines the cinematograph has just begun to be developed, and offers great possibilities in solving problems dealing with time and space in fields as wide apart as engineering and biology, and makes possible the study of motions so slow that it has hitherto been impossible to form conception of their whole meaning, or so fast that it has been almost impossible to form any conception of them at all.—*Journal of Industrial and Engineering Chemistry.*

Relative Bactericidal Power of Mercuric Salts

Mercuric iodide is found to be far more active as a bactericide than mercuric chloride, mercuric cyanide, or mercuric benzoate. It is at least ten times more powerful than mercuric chloride, which is generally considered to be one of the most active of all antiseptics.—*Comptes rend.*

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